

# WHOLESALE SUCCESS

**A Farmer's Guide to Selling,  
Postharvest Handling  
and Packing Produce**

**edited by  
Jim Slama**





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Photo: Jim Slama

Rebecca Bloom, Bloom's Organic Farms

We are very pleased to publish the National Edition of *Wholesale Success: A Farmer's Guide to Selling, Postharvest Handling, and Packing Produce*. Our Midwest edition quickly sold out and demand came in from across the country. As a result, we decided to update the publication to speak to growers from coast to coast. Our goal with *Wholesale Success* is to build the capacity of farmers to meet the burgeoning demand for locally grown fruits and vegetables. Adopting best practices in food safety, postharvest handling, packing, and business management will help farmers be more efficient and profitable. It will also give buyers an incentive to increase their purchases of locally grown food.

FamilyFarmed.org's mission is to expand the production, marketing and distribution of locally grown and responsibly produced food, in order to enhance the social, economic and environmental health of our communities. Here is a description of some of our programs:

### Market Development Program

FamilyFarmed.org now works with many of the nation's largest buyers of local food including Compass Group, Goodness Greeness, Chipotle, Sysco, Whole Foods

Market, Organic Valley, and others to connect them with local farmers and food producers. We also work with growers to build their capacity to sell into wholesale markets through training, education, and networking events.



### FamilyFarmed.org EXPO

FamilyFarmed.org produces the annual FamilyFarmed EXPO – a trade show, conference, and celebration of local and responsibly produced food. The purpose of the event is to link some of the Midwest's best local farmers and family-owned producers of food and farm products with the public, trade buyers, and leaders in the field to foster relationships that facilitate the growth of local food systems. In the coming years, we intend to work with regional partners to produce the EXPO in other markets.

### Food Safety

Food safety is key for farmers of all sizes, and taking this issue seriously will help to safeguard the growing local foods movement. As such, FamilyFarmed.org's On-farm Food Safety Project is creating a tool for small to mid-scale fruit and vegetable farmers to help them create a personalized on-farm food safety plan. This program will be available on the website [www.farmfoodsafetyplan.org](http://www.farmfoodsafetyplan.org)

Please contact us for Wholesale Success and On-Farm Food Safety speaking engagements and training opportunities: email [info@familyfarmed.org](mailto:info@familyfarmed.org) or call **708-763-9920**.

Thanks for your help in developing local food systems.

Jim Slama  
Founder and President, FamilyFarmed.org  
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photo: John Beske

# WHOLESALE SUCCESS

## A Farmer's Guide to Selling, Postharvest Handling and Packing Produce

### Introduction

As consumer demand for locally grown produce increases, more farmers are selling their products to supermarkets, distributors, restaurants, and institutions seeking to meet the demand of their customers. This manual is a guide to successful wholesaling as a small or mid-scale producer. It is a tool to help you build a number of skills that are key to success in this marketplace including: postharvest handling, cooling, packing, buyer-seller

relations, contracts, USDA grade standards, certification opportunities, food safety, and more. Ultimately, the information in this guide will help you develop new profitable business relationships, increase product quality, maximize shelf life, and successfully manage wholesale sales.

One of the most important aspects of wholesaling is proper postharvest handling, which can and often does make the difference between securing business relations or losing them based on the

## **Requirements for Selling Into Wholesale Markets**

**Field heat must be removed with proper cooling.**

**The “cold chain” must be maintained from the field to the customer with refrigerated storage of most fruits and vegetables.**

**Products must be sorted uniformly to match USDA grades.**

**Food safety procedures must be followed including necessary record keeping.**

**Buyers want larger quantities—many prefer pallets.**

**Production should yield a consistent weekly supply.**

**Producers must build relationships with wholesale buyers and stay in touch regularly to communicate issues such as timing, quantity, price, quality, etc.**

consistency and quality of harvested produce. Proper postharvest handling and packing techniques are a necessary part of any farming operation involved in wholesale, large or small.

The single most important aspect of postharvest handling of produce is lowering the core temperature of fruits and vegetables immediately after harvesting. Removing the “field heat” within a few hours after harvest makes the difference between a carrot which will keep for five days and one which will still be good five months later. While cooling infrastructure such as refrigerated storehouses and

hydro-cooling systems can be very useful, there are a number of very workable solutions for farmers who may not have the financial resources to purchase this sort of equipment. For example, harvesting in the early morning hours or even overnight takes advantage of the naturally lower air temperature, saving on energy costs and time. There are also ways to build your own cooling units and other postharvest equipment, which are detailed later on in this manual. At least some form of cooler is necessary for selling to a wholesale market.

In addition to the technical side of preparing your produce for wholesale buyers, this manual offers important advice on the marketing and business aspects, with input from both wholesale buyers and farmers who have been involved in regional wholesale markets. This section discusses business relations, contracts, long-term financial planning strategies, and more.

In order to apply this information to your farm and the crops you grow, the second half of the manual offers 101 in-depth crop-specific profiles, including basic information such as cleaning methods, optimal storage conditions and standard package sizes, and also more complicated topics such as sensitivity to ethylene.

Selling into wholesale markets presents an entire set of new opportunities and challenges compared to direct marketing or selling on the open market at a fairly fixed price. Carefully consider what you are looking for as a farmer and for what your farm operation is best suited. This guide aims to be an easy to use resource to help farmers grapple with new demands of selling, sorting, sizing, packing, shipping, cooling, and more.

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## Section 1: Selling Into Wholesale Markets

### Market Size and Opportunity

The market for local and organic food has been growing quickly in the past two decades. In recent years the demand for local food has become the hottest trend in the food industry. Supermarkets are adding major sections of locally produced food and showcasing it through in-store promotions that sometimes include pictures of the farmer. Some consumers now shop at stores specifically because they know they can purchase products from their favorite family farm.

A recent study, "Local and Fresh Foods in the US," published by Packaged Facts, indicated that the market for local foods was \$5 billion.<sup>1</sup> The analysis indicated that local food sales would likely grow to \$7 billion by 2011. The local food trend is attracting major institutional purchasers such as universities, hospitals, entertainment venues and more. This in

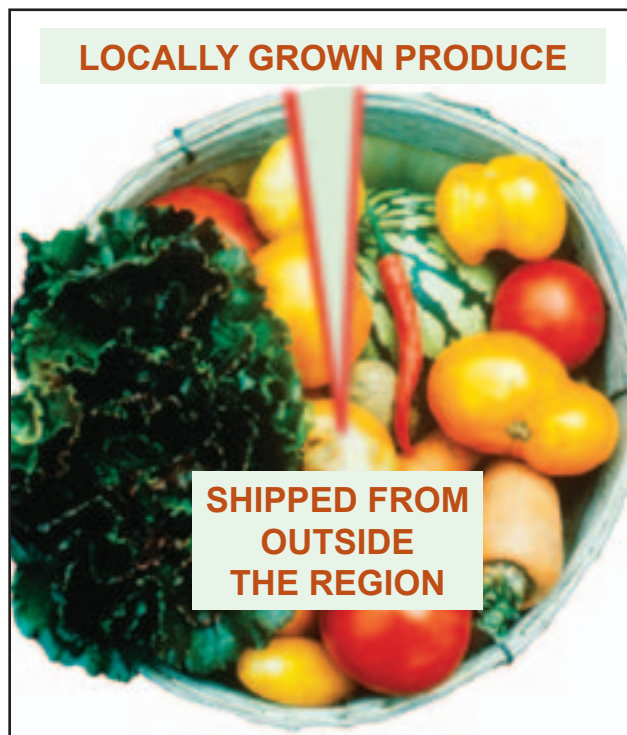
turn is convincing major distributors to offer locally grown fruits and vegetables to their wholesale customers. The result is a tremendous opportunity for regional farmers that have the means to grow high quality products of sufficient quantity to sell into these markets.

In Illinois, the Local and Organic Food and Farm Task Force determined that less than 5% of the \$48 billion in food purchased in the state came from local sources. Spurred on by that figure they passed a new law encouraging more local food production and consumption, especially by state agencies and schools who are encouraged to use 20% Illinois grown food by 2020.

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**"Locally Grown Food is the latest student cause. . . The new activist phrase on campus is Eat Local."**

*Time Magazine*<sup>2</sup>



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The market for organic food continues to grow as well. In 1990, US organic food sales were \$1 billion. By 2008, they had grown to nearly \$25, billion. With annual growth approaching 20% per year, organic has been the fastest growing sector in the food industry for the past two decades.

For example, in the Midwest alone, a per capita consumption analysis determined that organic food sales exceed \$2 billion.<sup>3</sup> Yet most of that food is grown outside the region. One study indicated that more than 95% of the organic food consumed in Illinois was grown out of state.<sup>4</sup>

## Selling into Wholesale Markets

A primary goal of this manual is to help more farmers capitalize on the opportunity to sell local and organic food into wholesale markets. Many of the biggest wholesale buyers in this marketplace are interested in developing new relationships with fruit and vegetable growers that can meet the demand for high quality produce.

For the producer, this is a big decision. Many produce growers use direct marketing business models for their farm – farm stands, farmers' markets, Community Supported Agriculture (CSA), or phone and internet sales. Wholesale markets present an entirely different set of obstacles and opportunities. For smaller producers who have primarily been selling into direct markets, the world of wholesale markets is very different. The price per pound for products sold wholesale is less than selling direct. You will have to make up for this drop in price with higher volume.

An increasing number of producers selling direct find the stability and high volume

sales in wholesale markets a major attraction. In some cases farms diversify their sales by keeping their most profitable or convenient direct market sales and adding wholesale accounts once the farm hits a certain size or they feel that the farm has the sophistication to meet the demands of wholesale buyers. In other cases, farms completely move out of direct markets and strictly sell to wholesale buyers. There are advantages and disadvantages to both.

This manual also addresses mid and large-scale fruit and vegetable producers who have historically sold produce directly to food processors. Competition from low-cost, foreign or out-of-region industrial-scale producers is cutting prices, sales and revenue for many mid-scale, independent farmers who have traditionally sold their products as commodities to food processors and manufacturers.

Supermarkets, restaurants, distributors, universities, hospitals, and other institutions looking for a more differentiated product mix represent a major opportunity for these producers to diversify their revenue stream and customer base. These producers have a different opportunity and set of challenges to selling wholesale. For them, the volume of products sold to one wholesale buyer will probably be far less than when selling to processors. As a result there will be more work in developing markets. Yet the price per pound will be much higher when selling into these markets rather than for processing. Prices are particularly higher when products are sold to those buyers seeking products that are local, organic, family farmed, ecological, etc. Wholesale buyers are now more willing to pay price premiums for those products that meet the values of their end customers, particularly if the name of the farm and the place of production can be used to promote the product at the point of sale.



photo: Alina Diddley



photo: Sustain

Will Allen of Growing Power.

## Characteristics of Wholesale Growers

It is helpful to evaluate your own personality and farm systems to determine your compatibility with wholesale marketing.

Gross income per acre is generally lower in wholesale production than direct-marketed, value-added retail. You will need to make up for lower prices with higher volume. This will require sufficient acreage of quality land for production. Do you have access to sufficient acreage of quality soil?

The increase in volume creates a stronger need for mechanization and scale of efficiency systems. If you are presently farming with labor-intensive hand systems, upscaling your volume without mechanizing your systems may prove to be excessively labor intensive and not economically viable. Do you have access to the necessary equipment and can you maintain it?

The increase in volume will also increase your need for hired help. Can you manage employees and delegate tasks?

Wholesale marketing requires a different set of personality strengths than direct marketing. You will be working with one buyer for larger sales instead of many smaller sales with individuals. Crucial to success is your ability to be professional: good communication and timely delivery; accurate forecasting of crop maturity and volume; consistency in clean, uniform, and high-quality product; and reliable and consistent volume which matches market demands. If you are a beginning farmer it is advisable to gain experience and develop your growing systems with farmers' market sales before entering the wholesale market. Individual purchasers are more forgiving in your beginning learning years than a busy wholesaler.

For some farmers, direct contact with the consumer is rewarding and an important part of their personal wellness. Wholesale relationships can fail to fulfill their need for social contact. For others, the release from retail sales is a relief and frees up time they prefer to spend in the field.

## Advantages and Disadvantages of Selling Into Wholesale Markets

### Advantages to wholesale

Most farmers who transition to wholesale find that the first two or three years are the most difficult, but that it is ultimately very rewarding once systems are in place and best practices have been established.

Some of the key benefits of wholesale include:

- Farmers have access to an established customer base in a market where there is strong and growing demand.
- Farmers that master the wholesale model for local and organic products can develop very profitable businesses with seven-figure income streams.

## WHOLESALE SUCCESS Section 1: Selling Into Wholesale Markets

- Farmers selling wholesale have streamlined storage and transportation needs.
- There is reduced product quality risk to farmers—the wholesaler assumes some of the risk.
- Farmers need more crop specialization, thus reducing the number of crops that need to be grown.
- The sales process is simplified because farmers typically sell to only a few buyers, thus cutting down on the interaction with customers needed in direct markets. Phone calls, electronic orders and invoicing require very little time and may provide a more stable income, unlike a farmers' market, for example, where daily demand is uncertain and dependent on factors such as the weather.
- Large wholesale accounts can purchase large quantities of product. This means the producer will receive large checks.
- Wholesale business can provide steady work for farm staff for regions with shorter growing seasons, particularly if cold storage crops are grown or seasonal extension is used.
- Farmers may have reduced labor, time, and fuel costs associated with driving into the city and managing one or more farmers' market booths or CSA routes.
- Farmers can still sell direct through farmers' markets and CSAs. With the increased revenue from wholesale markets, they can choose to limit direct sales to those venues which are most profitable and satisfying.
- Farmers still doing direct sales can in fact be more efficient since it is possible to consolidate delivery of CSAs, farmers' market, and wholesale items with more efficient trucking logistics.
- Wholesale markets are more capable of absorbing peak production and excess volume than direct retail markets.
- Diversity of markets can be a valuable tool for balancing sales to match production. If one market is not doing well the other often is. For example: in summer many farmers' markets' and roadside stands' sales increase, but when schools start back up in the fall buyers switch from farmers' markets to retail stores. By serving both markets you continue to serve the same customer but through different outlets.

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**Farmers need to devote a significant amount of time to planning and communicating with wholesale buyers.**

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### Challenges in Wholesale

Wholesale also presents its own challenges and obstacles. They include:

- Wholesale buyers usually only purchase a limited number of crops per farm and they demand a consistent supply.
- Many wholesale buyers prefer to purchase large quantities of product per farm. Ideally they want pallets—not boxes—of product.
- Wholesale buyers demand excellent postharvest handling and storage practices. This includes maintaining the “cold chain” from the field to their facility.
- Produce which may be suitable for farmers' markets and immediate consumption may not last long enough or meet the appearance standards in a wholesale market.
- Proper postharvest handling requires a serious investment in on-farm cooling and storage infrastructure.

# WHOLESALE SUCCESS Section 1: Selling Into Wholesale Markets

- Producers need to keep detailed records of temperature and storage conditions and other important measures.
- Wholesale buyers are increasingly demanding that farmers meet GAP and in some cases HACCP food safety protocols. There may be significant record-keeping requirements and time spent to meet these requirements. FamilyFarmed.org is developing free on-line and offline tools available to assist farmers in generating their own food safety plan based on GAP and HACCP protocols - please see section 7 for further details.
- Producers do not receive immediate payment when product is delivered. In some cases invoices are paid a month or later after delivery. Some buyers pay more quickly. Check with them first to find out what their terms are. When payments are later, farms will need to create good cash-flow management systems or relationships with banks that can finance the receivables.
- Competition with larger-scale farms nationally and internationally can drive down prices.
- There is little direct consumer contact. If you enjoy regularly communicating

directly with your buyers, as in a CSA or farmers' market setup, you may want to evaluate whether wholesaling is the right choice for your farm business.

- A large portion of your production is dependent on your relationship with one buyer. This makes you more vulnerable in a situation of loss of relationship. Don't put all your eggs in one basket. If a large portion of your product is going to one wholesaler be sure of the relationship commitment before overextending yourself.

## Building Relationships with Wholesale Buyers

Developing mutually beneficial relationships with your wholesale buyers is a crucial element for success. Wholesale buyers are busy people under a great deal of pressure. The easier you can make it for them to buy from you the more successful your relationship will be.

Generally it is best to contact wholesale buyers in the off-season or when harvest activities have slowed down. Beginning conversations can include who you are and a brief farm history. Sending a brief cover letter with contact information followed by a call can be a good way to start a relationship. Farm conference trade shows are a good opportunity to initiate a relationship.

Sometimes it is necessary to prove yourself to a buyer. They may have had negative experiences in the past working with local producers. If they seem to have an attitude don't take it personally. Offer to stop by at a time that is convenient for them. If it is in season, offer to drop off some samples with a price list and follow up with a phone call. Generally whole case samples are better than just one or two items. Whole cases



photo: Dennis Fiser

Connecting with buyer Greg Christian at the FamilyFarmed.org EXPO.



allow you the opportunity to show them that you know how to present a well-packed case of quality, uniform product.

Try to understand what pressures they are under and how you can best fit into their existing system rather than trying to change their system to meet your needs. Find out:

- What products and volumes they need.
- What form of communication they prefer: email, phone, or fax.
- The best time of the day and week for placing orders.
- Best time for deliveries.
- How much advance notice of availability is needed.
- What type of packaging they prefer.

Be sure to include price in your discussion. Knowing your cost of production will help you to determine a fair and economically viable price. Discuss in advance if you will be expected to match the volatile national market.

Before committing to plant for a wholesaler, it is wise to talk with other growers who have had experience with them. Do they have a history of following through on their agreements? Are they price pickers and box kickers? Can you count on them to purchase what they have asked you to grow? Do they have a reliable outlet?

Be realistic. Don't promise more than you can deliver. It can be difficult to convince a buyer to try your product once you have failed to deliver quality product. Set standards of reliability. Make sure that you deliver what and when you said you would. Meeting with your buyer every year in the off- or slow season is an important relationship-building tool. Provide a spreadsheet for the discussion showing

multiple-year sales. Ask how the season went, if there are changes they would like to see in the future, what you can do to improve your quality or service, and what volume to expect in the coming season.

Encourage them to communicate problems or concerns with you. Be willing to learn from their constructive criticism. You may find that a product which satisfied your farmers' market customers is not right for wholesale and adjustments need to be made. A good relationship can be educational both ways when trust is built.

Visit wholesale warehouses to see the business practices of distributors and also how other growers prepare product for markets. Wholesale buyers deal with large quantities of produce coming from areas all over the country and world. As a grower, these visits give you first hand knowledge of real-world practice.

### Crop Planning

Growing a smaller number of crops allows you to focus on streamlining your operation, producing high volumes of product at an acceptable cost, and ensures that you take advantage of the local soil and climate in the most effective way possible. There are a number of factors any farmer must consider when deciding which crops to grow.

Evaluate your soil and climate to determine what crops will do well on your farm. You will have a difficult time achieving success if you try to grow crops that are not suitable for your farm. For example: potatoes don't do well in clay soils; quality broccoli requires higher fertility, water, and organic matter than sand provides; and sweet corn has a low gross income per acre and requires mechanization and access to land. Be sure you match your



Photo: Glenda Kapsulis

crop plan to your farm soil types and mechanization.

Consistent supply is part of a healthy wholesaler-producer relationship. Coming in and out of the market is difficult to impossible for the buyer. If you don't have the product they will have to find it from another shipper. When you come back in you may find they are filled up with product from elsewhere and can't buy yours.

Evaluating the potential season of your crop is crucial for developing your planting sequencing plan. Know how long your crop can be harvested and how frequently you need to plant to ensure a steady supply. For example, a planting of sweet corn is generally harvestable for 3-5 days depending on temperature, moisture, variety and wind. Providing consistent supply requires sequencing of numerous plantings. Every crop will have a different period of quality harvest. There are many variables to consider in planning the frequency needed for planting. How quickly did the seed germinate or the transplant

establish itself? What will the temperature likely be at time of maturity? Crops ripening in fall coolness usually take longer to ripen than in summer heat. You can adjust the planting dates or the amount planted. Some crops like cucumbers and zucchini have a tendency to have inconsistent yields, starting out with small yields and peaking at a mid point in their harvest period. Consistency in this case can be achieved by overlapping plantings, having one just coming in with low volume and another at peak production.

It is important to include market sales variables in your sequence planning. Examples: people eat more watermelon in hot weather than cool, broccoli sales soar in the Midwest, for example, in fall with cooler weather. Study each crop's market demand. If you don't have experience you can obtain this type of information from your experienced buyer.

Acquiring an in-depth understanding of your crops' cultural needs and keeping accurate and detailed yield and weather condition records will help you fine-tune your sequence planting in the future.

When you are planning sequences, set a goal of a continuous steady stream of product from earliest possible to latest possible. For regions with shorter growing seasons, consider using season extension methods to achieve the earliest possible product and extend as late as possible in fall. Having a consistent and long season will firmly place you in your buyer's market as a reliable and valuable producer.

Establish your strategy. Are you comfortable with some surplus product in order to not lose an opportunity to satisfy your market? You may consider over planting 5-20%. This will make it easier to provide a steady supply in less than ideal conditions and

meet your buyer's needs more consistently. Do you prefer to plan tight for no waste? With this philosophy you could maximize gross income per acre and have little or no waste. You will also find yourself more likely to be in the position of having to apologize for having no product when the season is slow or cool and you are short.

While wholesale contracts can help insulate you from market price swings, there are several practical limitations that need to be considered when negotiating these contracts. One issue is what you are able to plant, in terms of labor availability, finances, and technology. Do not promise to deliver new crops in an attempt to capitalize on higher prices for particular products, particularly in the first couple of years. Once you have established yourself as a reliable supplier, then it may be prudent to set aside small parcels of land to experiment with alternative crops. Also, be very careful about promising yields that are dependent on new technology or equipment – it may indeed be worthwhile, but be aware of what you're getting into.

## Pricing

One key element for producers making the transition to wholesale selling is price. In some cases farmers used to selling into direct markets have unrealistic expectations about what price they can receive selling to restaurants, distributors, or supermarkets. Farmers should not expect to sell their products at retail or even near retail prices. The key to profitability in wholesale markets is volume and consistent sales. This is an important point to remember.

You should not presume that you can "grow what you want" and charge whatever prices are necessary to cover your margins. As a participant in the wholesale

market, you are competing with national and international suppliers, and properly managing your operation will allow you to compete in that context. While local and certified organic production do give you a market advantage, they alone will not compete with cheaper prices for produce coming from Mexico, or other well-established produce-growing regions.

National pricing can be volatile. In some regions the season can be too short to rely on a high price period to make up for a low price period. It is crucial that you know what your cost of production is. You cannot stay in business if you are selling below it. Communicate with your buyer as to your pricing agreement and their pricing policy. Will they only buy from you when you are the cheapest available product? You may not want this relationship. Are they able to recognize and market the added value of your quality, local product and pay a consistent price that is a fair local price? This is the type of relationship that will be mutually beneficial and upon which you can build your wholesale business.

For an overview of common wholesale market prices, including organic products, farmers can look at terminal market price reports. The USDA Agricultural Marketing Service publishes daily market price reports, which are freely available online at [www.ams.usda.gov/fv/mncs/fwires.htm](http://www.ams.usda.gov/fv/mncs/fwires.htm). Reports are sorted by crop type and terminal market location.

## Negotiating Contracts/Grower Agreements

Consider whether or not you want to have a written agreement. It can be valuable to have written expectations and agreements on paper to prevent future misunderstandings. A

written agreement also provides continuity if the buyer you have a relationship with leaves the business and you need to reestablish a relationship with a new buyer. If you are new to wholesale you may want to acquire some years of experience before agreeing to the commitment that a written agreement creates. You also may want to have more flexibility in markets and not commit to a set volume and relationship with your wholesale buyer.

Some buyers may be uncomfortable signing written agreements, especially if they do not have an established relationship with you and do not know from experience if you can deliver the goods. Your agreement can and should include benefits for the buyer as well as yourself.

Important details to include in agreement:

- Names of parties and business names
- Date agreement was written
- Crops and amounts, which will be produced and purchased
  - o Which specific variety you will be growing
  - o Sizing of the variety
- Whether or not you are required to provide product in the event of the loss of your own
- For organic farms: a commitment to maintain organic certification
- Expected delivery schedule
- Amount of advance product availability notice
- Pricing agreement and policy
- Pack sizes, count and weight
- Payment schedule (by law growers must be paid within 21 days, although through the agreement you can accept later payments; 30 days is standard)

- Product Standards
- Signatures

Additional issues you may wish to discuss and include:

- General liability insurance carried by the farmer (generally for at least \$1,000,000. Sometimes the wholesaler will ask to be named on the policy as additionally insured)
- Postharvest requirements of the buyer
- Product exclusivity agreements
- Reassurance that you will plant and deliver a specific amount of product for buyer

An example of a grower agreement is included in the appendix. Please consult an attorney before execution.

### Calculating Return on Investment

In planning production, it is important to look at the profitability of selected crops and crop sizes. A number of factors must be considered including current production profitability, production inputs and other miscellaneous costs, and the projected income from the crop. This can be done by hand using spreadsheet tools, or using an online calculator such as the Iowa State University “Produce Profitability Calculator” created by the Leopold Center for Sustainable Agriculture. This can be accessed at [www.iastatelocalfoods.org/calculator](http://www.iastatelocalfoods.org/calculator), with a detailed instruction manual at [www.leopold.iastate.edu/research/marketing\\_files/profitability\\_0108.pdf](http://www.leopold.iastate.edu/research/marketing_files/profitability_0108.pdf).<sup>5</sup>

Regardless of the method used to calculate profitability for a particular crop, profitability of both the current crop production and of the anticipated future crop production should be calculated in order to compare the returns on investment. The calculations should include the following steps:

# WHOLESALE SUCCESS Section 1: Selling Into Wholesale Markets

## Organic Potatoes: Farmers' Markets and Wholesale Markets

This example uses the Leopold Center's Return on Investment Calculator to look at a farmer who moves from 1/10 acre of potatoes sold at a farmers' market to 20 acres of potatoes sold into wholesale markets.

Profitability Calculation Example							
Step 1: Levels of Pro- duction	Crop: <b>Organic Potatoes</b>			CURRENT PRODUCTION		EXPANDED PRODUCTION	
	Units produced (lb):			1,600		320,000	
	Current acres of crop:			0.1		20	
	Total acres in production:			100		100	
	Percent acres in this crop:			0.10%		20.00%	
Step 2: Income				CURRENT PRODUCTION		EXPANDED PRODUCTION	
	<b>Sales Method</b>	<b>Unit</b>	<b>\$/Unit</b>	<b>Quantity</b>	<b>Item total</b>	<b>Quantity</b>	<b>Item total</b>
	Direct-Wholesale	Bag	\$0.45	0	\$0.00	320,000	\$144,000.00
	Farmer's Market		\$2.00	1,600	\$3,200.00	0	\$0.00
	<b>TOTAL INCOME</b>				<b>\$3,200.00</b>		<b>\$144,000.00</b>
Step 3: Costs				CURRENT PRODUCTION		EXPANDED PRODUCTION	
	<b>Production Costs</b>	<b>Unit</b>	<b>\$/Unit</b>	<b>Quantity</b>	<b>Item total</b>	<b>Quantity</b>	<b>Item total</b>
	Fertilizer		\$0.28	50	\$14.00	10,000	\$2,800.00
	Seed		\$0.60	200	\$120.00	40,000	\$24,000.00
	Fuel	Acre		0.1	\$8.00	20	\$1,600.00
	Labor	Hours		10	\$120.00	110	\$1,320.00
	<i>Production Costs Subtotal</i>				<i>\$262.00</i>		<i>\$29,720.00</i>
				CURRENT PRODUCTION		EXPANDED PRODUCTION	
	<b>Harvest Costs</b>	<b>Unit</b>	<b>\$/Unit</b>	<b>Quantity</b>	<b>Item total</b>	<b>Quantity</b>	<b>Item total</b>
	Bags	Bag	\$0.02	1,600	\$24.00	320,000	\$4,800.00
	Labor	Hours		16	\$192.00	360	\$4,320.00
	<i>Harvest Costs Subtotal</i>				<i>\$216.00</i>		<i>\$9,120.00</i>
				CURRENT PRODUCTION		EXPANDED PRODUCTION	
	<b>Post-harvest Costs</b>	<b>Unit</b>	<b>\$/Unit</b>	<b>Quantity</b>	<b>Item total</b>	<b>Quantity</b>	<b>Item total</b>
	Shipping		\$0.04	1,600	\$64.00	320,000	\$12,800.00
	Labor - sorting and bagging	Hours		10	\$120.00	384	\$4,608.00
	<i>Post-harvest Costs Subtotal</i>				<i>\$184.00</i>		<i>\$17,408.00</i>
				CURRENT PRODUCTION		EXPANDED PRODUCTION	
	<b>General Costs</b>	<b>Annual cost</b>	<b>Crop pro- duction</b>	<b>Cost for crop</b>	<b>Crop pro- duction</b>	<b>Cost for crop</b>	
	Machinery payment	\$15,000.00	0.1%	\$15.00	20.00%	\$3,000.00	
	Land rental	\$44,000.00	0.1%	\$44.00	20.00%	\$8,800.00	
	Facilities - rental	\$10,000.00	0.1%	\$10.00	20.00%	\$2,000.00	
	Facilities - utilities	\$5,000.00	0.1%	\$5.00	20.00%	\$1,000.00	
Insurance - product liability	\$30,000.00	0.1%	\$30.00	20.00%	\$6,000.00		
<i>General Costs Subtotal</i>				<i>\$104.00</i>		<i>\$20,800.00</i>	
<b>TOTAL COSTS</b>				<b>\$766.00</b>		<b>\$77,048.00</b>	
Step 4: ROI				CURRENT PRODUCTION		EXPANDED PRODUCTION	
	Return after costs:			\$2,434.00		\$66,952.00	
	Units produced (lb):			1,600		320,000	
Return per unit produced:			\$1.52		\$0.21		

# WHOLESALE SUCCESS Section 1: Selling Into Wholesale Markets

Step 1 – Levels of Production: Record the current and future crop production level, including number of units produced, acreage produced on, and the percentage of acreage in relation to the entire farm's production area. These baseline figures will be used throughout the rest of the calculations.

Step 2 – Income: For each sales method you plan to use (farmer's markets, wholesale, etc.), determine what portion of the crop will be sold using this method, and expected price per unit. This can then be used to calculate the total income for the crop.

Step 3 – Costs: There are many costs that need to be accounted for in growing, harvesting, and selling a crop:

- Production costs: These include seed, fertilizer, labor etc. The number of units and the price per unit should be entered for each input. The total production cost can then be calculated.
- Harvest costs: These include bags/boxes, labor, etc. These should be calculated as with production costs.
- Postharvest costs: These include fuel, labor, and all other transaction costs needed to market and sell the crop. These should be calculated as with production costs.
- General costs: These include costs related to machinery, land rental, facilities, insurance, or any other costs that apply to the farm as a whole. The portion of these costs attributed to a particular crop can be calculated by multiplying the percentage of acreage of the crop by each of the general costs.

Step 4 – Calculating return on investment: By subtracting the total costs from the total income, the profitability of the crop can be determined. Similarly, the profit per unit

of the crop can also be computed. The profitability of the current crop level can now be compared to a future desired level, and this can ultimately help you make the decision of what and how much to plant depending on your markets.

## Timing

In direct marketing, farmers often grow a wide variety of crops and sell each crop in a relatively short period of time. In wholesale, you will grow fewer crops that will need to be available for a longer period of time. Harvesting all of one crop at once is undesirable for the wholesaler, who can only move a certain quantity in any given period of time, but also negatively influences farmers throughout the region, who are forced to deal with a sudden glut of supply and rapid drop in price. Wholesalers will turn down produce they do not have the capacity to sell.

In addition, you need to provide advance notice of when you have a certain quantity of produce available. Wholesalers will be ill-prepared to deal with a sudden increase in supply with no notice, generally preferring a week or two advance notice. This means that the wholesale buyer is often booked for supply at least a week in advance, and you will need to give them a week or more notice that you are expecting a certain amount of product to be available. Many wholesalers will prefer local suppliers, but only with adequate notice so that they can hold off on making orders to traditional large-scale suppliers elsewhere.

Sequencing your crops has two major benefits: you will have a continuous supply, which helps the wholesaler secure shelf space for your product in the stores, and you will be able to capitalize on price premiums for early and/or late season

# WHOLESALE SUCCESS Section 1: Selling Into Wholesale Markets

availability. For example, in the Midwest, the market price for zucchini usually falls dramatically in mid-July. By sequencing crops, growers will be able to sell zucchini for a higher price later in the season, starting around mid-August. Season extension practices such as greenhouse production in regions with short growing seasons can add even more value to the product.

Accurate forecasting of crop maturation is challenging but critical. Heating degree-days, amount of sunshine, and amount of moisture are variables which affect maturity date but are beyond the producer's control. Keeping detailed yield and weather conditions records will help you learn forecasting. Recording photographs of crops in various stages of maturity along with records detailing weather and days from maturity are very valuable in the future for accurate forecasting.

Wholesale buyers do not have an unlimited capacity to absorb and re-sell produce, and as a farmer you must plan your growing practices accordingly. Keep an eye on your crops and how quickly they are maturing. Let your wholesaler know as soon as possible when the crop will be ready for harvest and pick-up; they will be able to set aside space for your produce and ensure that there are enough secured buyers to purchase all of it.

## Shipping

Product shelf life is dependent on maintaining proper temperatures and protecting product from bruising during shipping. If you do your own trucking be sure you are able to protect your product. Alternative options to running your own truck can include paying for pallet space on courier trucks. You can also ask your buyer if they



photo: Jim Slama

Lady Moon Farms.

already have trucks delivering anywhere near your farm. You may be able to arrange on-farm pick-ups to back haul your product back to the shipper. Some buyers like Whole Foods Market, Goodness Greeness, and Veritable Vegetable may arrange to pick up a product on a farm on the way back to their warehouse if they have an empty truck. This back hauling can be part of up front pricing and shipping discussions to see if it is feasible. Whether using your own truck or a buyer's truck, a loading dock or a fork lift is generally required.

## Shipments Refused for Quality Problems

Good quality product is a key to success in selling into wholesale markets. In the unfortunate event that your buyer is claiming poor quality and does not want to accept your product there are USDA regulations and inspectors who can be brought in to evaluate the product.

## PROCESS:

- The buyer notifies shipper of quality problems.
- The shipper can request a USDA federal inspection.
- An inspector examines the product and evaluates it to USDA quality standards. These standards are the same for organic and conventional produce.
- If the outcome favors the shipper the buyer pays the inspection fee and is required to pay the shipper for the product
- If the outcome favors the buyer the shipper pays the inspection fee. The buyer can refuse the product or work out a price reduction.

## Fulfilling Orders and Record Keeping

One very simple step which can help improve the relationship with your buyer is establishing a clear protocol for handling orders, shipments, and invoices. Discuss with your wholesale buyer whether email, fax, or phone works best, and feel free to specify which is best for you personally. Anytime the wholesale buyer places an order, respond to confirm; many farmers overlook this key step, and the wholesaler is left not knowing whether the order will be completed or not.

Keep records of invoices, receipts, and order confirmations. This way, if there is any miscommunication, you can clearly show that all of the proper steps were taken, and you can identify where the problem occurred (e.g. if the wholesaler misplaced the order form).

It is a good idea in general to keep a daily log; not only can this be helpful for keeping the records needed for selling to

a wholesaler, it is an essential part of good farm management. It can make organic certification and other certifications easier, and can be used to help plan production. Simple spreadsheets can help track seed orders, production methods, and harvest amounts. Increasingly buyers are demanding that producers follow food safety protocols such as GAP and HACCP. Make sure you check.

## Billing

You should invoice as close to shipment as possible, preferably with shipment. Two copies should be made, one for you and one for the buyer, both of them signed by the receiver. Develop a regular invoice/payment/delivery schedule. Pick a regular time interval to send in invoices that are due. Follow-up on those if you don't receive a response within a reasonable amount of time. It is always prudent to keep a SIGNED copy of accepted invoices.

For any delivery of produce to a buyer, there are 4 steps involved in the billing process:

- 1. Confirmation of the buyer's order.** It is important to respond to the buyer by email, phone, or fax, and let them know that you will or will not be able to fill the order they requested. Without this essential step, many buyers are left wondering whether or not you will deliver.
- 2. Pending invoice.** A day or so before shipping, it is good practice to send the buyer a copy of what you expect the invoice to look like.
- 3. Packing slip with shipment.** A packing slip should be attached to the shipment. It should include the number of boxes of product, and the number of pallets they go on. It should also explicitly state if the produce is organic.





photo: Jim Slama

**4. Final invoice.** The final invoice should be sent to the buyer, with a copy to your bookkeeper.

conditions, which are still fresh in your and your buyers' minds.

## Postharvest Crop Planning

Fall and winter months are ideal for planning next year's crop with your wholesale buyer. The buyer will still have a clear sense of the year's sales figures, and will be able to tell you how certain crops performed in the marketplace, so you as a grower might maximize your profit by slightly shifting your production to a higher portion of certain crops, and a smaller portion of others.

Another reason to engage in postharvest planning is the availability of seed. While seeds do remain available into the early portion of the year, they often become noticeably more expensive as supplies dwindle. For organic growers who purchase seed, seed is usually sold out by February or even mid-January. It is important to begin planning in fall and early winter to prepare for next year based on current sales

## Organic Certification

Organic agriculture and organically grown or raised products have rapidly grown in popularity over the past several years, in part due to a growing consumer awareness of the environmental, health, economic, and social benefits of sustainable farm practices. Market surveys indicate that over two-thirds of consumers have purchased organic produce. Certified organic cropland has expanded as well, from less than 1 million acres in 1992 to over 4 million in 2005.<sup>6</sup> Farmers are taking advantage of the price premiums for crops and livestock raised without synthetic chemicals, antibiotics, or synthetic fertilizers, as well as the savings by not purchasing as many inputs. Organic farming has been shown to provide comparable or superior yields to conventionally managed fields, particularly in drought years, increase soil fertility and reduce soil erosion, and encourage biodiversity.

# WHOLESALE SUCCESS Section 1: Selling Into Wholesale Markets

While several certifying agencies were operating as early as the 1970s, the variety of standards led to a number of problems. Agencies would not always recognize other agencies' certification, which was highly problematic for processors and livestock producers sourcing ingredients or feed from several sources. Furthermore, the integrity of the organic certification process was undermined by several cases of fraud in the 1980s. The Organic Foods Production Act of 1990 set out to create national standards and create a uniform system for verifying that farm products met these standards. The final regulations have been in place since 2002, and this section will discuss the why and how of organic certification, from selecting a certification agency to record-keeping practices. Many farmers, including those who are not certified organic, can benefit from some of the practices outlined below.

## What is Organic?

According to IFOAM, the International Federation of Organic Agriculture Movements, "the role of organic agriculture, whether in farming, processing, distribution, or consumption, is to sustain and enhance the health of ecosystems and organisms from the smallest in the soil to human beings."<sup>7</sup>



In the United States, organic production standards are regulated by the National Organic Program (NOP) Final Rule: see <http://www.ams.usda.gov/AMSv1.0/nop>. The USDA NOP currently recognizes 100 organic certification agencies nationwide. Some organic certifying organizations include California Certified Organic Farmers (CCOF), Baystate Organic Certifiers and Midwest Organic Services Association. Go to the above website link and click on the "Certifiers" link in the gray textbox

to the right. This will pull up a page which provides a link to USDA Accredited Certifying Agents. Here you can search for Certifiers by state. The site also provides information on what commodities each organization can certify.



Organic agriculture is much more than what inputs you cannot use. While many materials are prohibited in organic production, organic production practices are often designed to reduce or eliminate the need for many of those materials in the first place. Examples of preventive measures include planting wildflowers on the periphery to support populations of beneficial insects that prey upon crop pests. Livestock can provide a steady source of nutrient-rich fertilizer for crops, and livestock raised on a more natural diet will remain healthier for longer periods of time, reducing the need for medical intervention. Organic agriculture is not merely input substitution, but a systematic approach to farm management in which all aspects of the farm interact with one another.

## Transition to Organic

Transitioning to organic production is often a daunting prospect for farmers, but it does not need to be especially difficult. There is a growing body of knowledge and research about how to transition farmland to organic production without losing productivity and money. Often, the largest perceived obstacles to transitioning are the financial hit associated with the decline in crop yields as the soil returns to a healthy state; implementing new pest and weed controls; and the learning curve involved with a new farming system. However, recent studies have taken advantage of the increasing number of farmers who have switched to

organic production and are discovering that yields do not necessarily decline during the three year transition\*. The increase in costs is furthermore offset by the price premiums for certified organic crops.

For farmers transitioning to organic, you must make sure that the land in question has not had prohibited substances on it for at least three years prior to the harvest of the crop to be sold as organic. This requires specific documentation certifying the last date of prohibited substance application as closely as possible. For example, if you know that you last applied pesticides sometime in the Spring of 2005, the earliest you can harvest certified organic crops is June 21, 2008 (the beginning of the summer season). However, if you know that the last pesticide application was on April 15, 2005, you can harvest organic crops starting April 16, 2008.

As a general rule, organic production regulates natural and synthetic substances in the following manner: natural substances are allowed unless explicitly prohibited and synthetic substances are prohibited unless explicitly allowed. Genetically modified seeds and treated seeds are not allowed under any circumstances. Both during transition and certified organic production, you will need to document that the inputs are allowed under organic regulations. Keep all relevant seed tags and purchase receipts as proof.

You may register with a certification agency at any time during these three years, but allow at least six months for application paperwork, initial inspections, the time required for the agency to process that information, and an opportunity to ask any questions about the process. Some farmers

register early on so that they have a clearer sense of what to expect from the certification and audit process, but this is not necessary. During transitional years, you must adhere to all organic regulations and must keep records like any organic farm operation.

### **Record-keeping**

Many farmers looking into organic production are worried that they will be required to keep extremely detailed records and fill out large amounts of paperwork, cutting into time that could otherwise be spent working on the farm itself. While organic producers are required to keep records, they are by no means unmanageable and in fact turn into an invaluable resource for the farmer. Records allow farmers to plan for future years and improve their farm practices. By knowing when the first cucumber beetles appear, for example, farmers can plant different crops at that time of year to avoid infestation. Also, and perhaps more importantly, farmers can track how the market responds at different times of year to various types of produce. If you are good at producing a certain crop outside of its common season, you can often receive a high price premium on the market.

While organizations like ATTRA, Extension offices, and certification agencies may offer sample record-keeping forms, often the best way to keep records is a simple daily journal. By entering the day's activities – inputs, crops that were planted, harvested, stored, or sold, which fields are having problems with insects or disease – you begin creating a long-term historical record of your farm ecosystem. Also, you have all of the information in a form that is both comprehensive and understandable for you and the inspector.

## Application and Selecting a Certification Agency

The application typically takes several hours to complete, and may cover everything from water conservation to biodiversity. A central portion of any application is a comprehensive farm management plan including pest control, crop planning, and natural resource management. Make sure that you have developed such a plan, and use the application form to help ensure that you have all of the necessary aspects planned out.

The entire application process often costs between \$400 and \$800, though costs can range up to \$1,000 in some circumstances, such as if yours is the only farm in the area visited by the inspector, or if you fail to furnish the complete set of required documentation in a timely fashion.

The Midwest Organic and Sustainable Education Service (MOSES) has a great generic fact sheet on how to choose an organic certifier at: <http://www.mosesorganic.org> Additionally the Rodale Institute has an online tool which allows you to select certifiers based on your selection criteria or to compare certifier attributes at [http://www.rodaleinstitute.org/certifier\\_directory](http://www.rodaleinstitute.org/certifier_directory). Both MOSES and the Rodale Institute also have a program to support conventional farmers to transition to organic. For more information check [www.mosesorganic.org](http://www.mosesorganic.org) and <http://www.tritrainingcenter.org/course/> respectively.

## Cost-Share

Several states have cost-share programs to help defray the costs of organic certification fees. The USDA allows producers to receive the lesser amount of either \$500 or 70% of certification fees. Check with your state Department of Agriculture for more information.



## Branding

Locally grown produce has an advantage in the marketplace – consumers generally prefer it to produce grown in far away locations, and restaurants and foodservice organizations are looking to improve their “green” image. A few private label brands have started to include farm names and contact information on the product packaging or price labels. Whole Foods Market, for example, often has posters of farmers who supply produce to their company. Hy-Vee grocery stores include farm logos and other information on some of their private label items.

Packaging is an unknown for many small farmers, particularly those who have historically dealt directly with consumers willing to buy variable amounts in bulk, unpackaged. Retailers and wholesalers are increasingly requiring labels and ID tags in the interest of fast, convenient, and efficient inventory control. By applying appropriate labels on your packaging, you will help wholesalers get a better sense of how well or poorly certain products are selling, which they can relay to you when you are making crop decisions for the following year.

## Local Labels

A number of organizations across the country offer local labeling programs. For example:

### Food Alliance

The Food Alliance operates nationally and offers several different certification programs, one such program is the Farm & Ranch Certification Program which incorporates a local labeling program.<sup>8</sup>



### Farm & Ranch Certification Program

The Food Alliance offers farmers and ranchers a certification and labeling program to differentiate sustainably produced food from conventional products. Their standards use a rating system to encourage the following:

- Safe and fair working conditions
- Healthy and humane treatment of animals
- Raising animals without added hormones and antibiotics
- Crop production without genetically modified organisms
- Reduced pesticides usage and toxicity
- Conservation of soil and water resources
- Preservation and protection of wildlife habitat
- Commitment to continuous improvement of these practices.

For more information on the program go to: <http://www.foodalliance.org>

### Red Tomato

Red Tomato, a small nonprofit in Massachusetts, is marketing agent for a network of 40 mid-size farms in the Northeast. RT coordinates sales, marketing

and logistics to bring their products into more than 200 supermarkets in the greater Boston and NYC metro area. To satisfy farms and deliver high-quality produce to retailers and distributors, Red Tomato's value-added strategy is to differentiate products, or decommodify them, through branding, local and farm identity, packaging, variety and diversity, eco certification, aggregation, and through intense focus on quality control to maximize flavor and freshness. As part of this strategy, Red Tomato offers a local labeling program for various commodities including the Eco Apple™ label as well as the Red Tomato logo and Born & Raised Here tag.



For more information on the program go to: <http://www.redtomato.org/index.php>



## Price Look Up (PLU) and Universal Product Codes (UPC)

Check with your buyer as to whether PLU numbers are required. PLU stickers can be purchased preprinted or a price gun can be used as a changeable number labeler. If PLU stickers are required, include sheets or strips of stickers in the boxes of produce.

Increasingly, wholesale buyers and retailers are taking advantage of PLU and UPC labels to manage their inventory, track purchases, identify sales trends, and

# WHOLESALE SUCCESS Section 1: Selling Into Wholesale Markets

increase the overall efficiency of their operation. As a grower, using PLU and UPC codes gives you more credibility and legitimacy in the wholesale market. A buyer will choose the labeled items when faced with a choice between labeled and unlabeled produce of similar quality.

PLU codes are 4 or 5-digit numbers printed on produce labels which were first used in the 1990s to make grocery store check-out and inventory control easier, faster, and more accurate. PLUs allow cashiers to quickly obtain the price of produce, nuts, spices, and other bulk goods. They also help differentiate between produce that appears similar or identical, but has different prices, such as organic and non-organic items or different varieties of a single produce item.

## Printing PLU Codes <sup>9</sup>

Make sure to only use PLU codes on bulk (loose) products, not products which will be sold in pre-weighed containers or bags. If you are designing and printing your own PLU stickers, there are a few guidelines for doing so.

PLU codes consist of 4 digits, typically in the 3000-4000 range. Visit [www.plucodes.com](http://www.plucodes.com) to ensure that you have the most up-to-date codes. The numbers 8 and 9 are currently the only approved prefix numbers for PLU codes. '8' designates genetically modified produce, and '9' designates organic produce. For example, organic bananas carry the number 94011, with '9' for organic, and '4011' for the standard PLU code for bananas.

- Make the 4 digits of the code as legible as possible; use at least a 14-point font. There is no upper limit on font size. Do not make the label width less than 1/3 of the height, and print the number in high contrast to the background (e.g., black text on white, or yellow text on blue).



Keep in mind that the cashier should be able to clearly read the label through a semi-transparent plastic bag. Large and bold fonts help make the label more legible.

- While you may include auxiliary information on the PLU label, such as the name of your farm or logo, the main purpose of the label is identification, and auxiliary information should not detract from the PLU number itself.
- When using a prefix number, particularly for organic produce, keep in mind the fact that many cashiers overlook the prefix number. You should clearly identify the product as organic in order to make sure that the product is sold at the correct price.
- While English is generally accepted as a marketplace standard, be aware of any regional market requirements. Quebec, Canada, for example, requires the addition of information in French if there are translations for the English words.
- The label adhesive should not cause the fruit or vegetable skin to come off, nor should it be located on a non-obvious part of the produce.
- Label adhesive must be food grade.

While PLU codes are often applied by wholesalers or retailers, farmers who grow less common crops or varieties may find it beneficial to adhere PLU labels to their produce to encourage wholesale buyers to purchase it.

PLU codes can be obtained from the Produce Marketing Association online at [www.pma.com](http://www.pma.com).

## Selling Through Cooperatives

Providing the volume required for many wholesale markets can be daunting for most farmers. It may not seem financially feasible when you calculate the costs of refrigeration, cooling, trucks, labor, and record-keeping. By cooperating with other farmers in your community, you can justify these costs and collectively reap the benefits of selling to wholesale buyers.

- **Organization.** Cooperatives may be formal or informal; you are not required to register cooperative partnerships. The most common organizational plan of a cooperative is centralizing one or more processes at each location. One farm may provide the trucks, one may offer refrigerated storage, another may have precooling facilities. Keep in mind the importance of rapidly cooling produce, however, and make sure that refrigeration and pre-cooling are accessible within a short period of time.
- **Volume.** Cooperative harvesting, storage, postharvest handling, and packing are common among Amish farmers, who live in inherently cooperative communities. While they hire third-party trucks to do the shipping, many Amish communities regularly deliver several truckloads of produce per shipment over an entire growing season.
- **Pooling.** By combining your produce with other farmers, you have a much higher chance of entering a market.



Cooperatives are able to supply a wider variety of produce, and even if one farm suffers crop losses due to weather or pests, collectively you will still be able to secure shelf space and sell product.

- **Marketing.** Many farmers are not interested in taking on marketing responsibilities. In a cooperative, there will likely be one individual who is capable and willing to handle marketing, invoicing, and sales for the entire group.

Co-ops take an enormous portion of risk off of the farmer's hands. The co-op assumes responsibility for storage, shipment, re-packaging and processing; this allows you as a farmer to devote more time towards doing what you do best – growing food. The only additional work that is required is proper postharvest handling and packaging. You should expect to pay for this service.

## Foodservice Sales

Beyond traditional venues for locally grown produce, such as wholesale brokers, direct marketing, and retail outlets, there is a rapidly growing demand for local produce in the foodservice sector. Foodservice buyers include commissary kitchens, schools and universities, hotels, and restaurants. Their needs differ from retailers in that they typically require at least minimal processing of their foods. While a grocery store will accept carrots or beets with stems and greens still attached, foodservice companies will prefer pre-cut produce. Often, any postharvest practices beyond simply cooling and washing produce counts as processing. If you are selling food which is "processed" in this regard, make sure you meet all relevant state and national guidelines for food processors.

## Section 2: Postharvest Preparation

### Influence of Preharvest Factors on Postharvest Quality

Obtaining the optimum postharvest quality of vegetables actually begins very early in the farm planning process. The effects of preharvest factors on postharvest quality are often overlooked and underestimated. However, many of the decisions that growers make during crop production can greatly influence the postharvest quality of crops. It is critical to remember that vegetable quality is only maintained postharvest – it is not improved during the harvest and storage processes. Thus, it is of utmost importance to consider the preharvest factors that allow growers to maximize the quality of the vegetables going into storage. These factors encompass production and management decisions concerning soil fertility, variety selection, irrigation, and pest management.

### Soil Factors

Maintaining good, long-term soil health and quality remains a primary goal of organic production systems. Achieving this goal will ultimately benefit the postharvest quality of vegetables grown on the farm. The availability of the optimal levels of plant nutrients throughout the growing season will allow for optimal quality of the vegetables throughout the packing and distribution processes. Deficiencies or overabundances of certain plant nutrients can affect positively or negatively a crop's susceptibility to physiological disorders, disease, and negative composition and textural changes. When optimizing soil fertility to improve postharvest quality, it is important to remember that these may not be the same soil nutrient levels that produce the highest yields.



Photo: Wisemandarine, Flickr URL: [www.flickr.com/photos/wisemandarine/2305808096/](https://www.flickr.com/photos/wisemandarine/2305808096/)

### Nitrogen

Nitrogen is an important mineral element that is used by almost all crops. Nitrogen, as a key component of plant proteins, plays an important role in plant growth and development.<sup>1</sup> Because of nitrogen's involvement in protein synthesis, soil nitrogen deficiencies may lead to lower protein concentrations in vegetables, thereby affecting the nutritional composition of the crop. Adequate soil nitrogen supplies allow for the optimal development of vegetable color, flavor, texture, and nutritional quality.

Excess soil nitrogen can be problematic as well. Research has shown that too much soil nitrogen can reduce the vitamin C content of certain crops. Excess nitrogen may lower fruit sugar content and acidity.



In certain situations, leafy green plants may accumulate excess soil nitrogen, leading to high concentrations of nitrates in the harvested greens.

Specific examples of excess nitrogen negatively affecting crop quality include:

- Altering celery flavor
- “brown-checking” of celery
- Increasing weight loss of sweet potato in storage
- Increasing hollow stem in broccoli
- Increasing soft rot in stored tomatoes

### Phosphorus and Potassium

Phosphorus and potassium also play very important roles in plant growth and development. Phosphorus is a key component of DNA and plant cell membranes. This element also plays a key role in plant metabolic processes. Potassium is important in plant water balance and enzyme activation.

High levels of soil phosphorus have been shown to increase sugar concentrations of fruits and vegetables while decreasing acidity. Excess soil phosphorus also may alter color of veggies. Phosphorus deficiencies can lead to rusty brown lesions on potato tubers. In cold weather, phosphorus deficiencies can show up as slight purple coloring. Phosphorus is less readily available in cold weather.

High levels of soil potassium often have a positive effect on the quality of vegetables. Increased soil potassium concentrations have been shown to increase the vitamin C and titratable acidity concentrations of vegetables and improve vegetable color. Potassium also decreases blotchy ripening of tomatoes.

### Calcium

Elemental calcium is important to plant cell walls and membranes.<sup>2</sup> Deficiencies in soil calcium have been associated with a number of postharvest disorders, including blossom end rot of tomato, pepper, and watermelon; brownheart of escarole; blackheart in celery; and tipburn of lettuce, cauliflower and cabbage. High soil calcium concentrations reduce these disorders and are associated with other postharvest benefits, including increased vitamin C content, extended storage life, delayed ripening, increased firmness, and reduced respiration and ethylene production.

### Soil Texture

The texture of the soil on which certain vegetable crops are grown may also affect the postharvest quality. For example, carrots grown on muck soils have been shown to have a greater concentration of terpenoids, a chemical that imparts a bitter flavor, than carrots grown on sandy soil.

### Irrigation

Adequate soil moisture during the preharvest period is essential for the maintenance of postharvest quality. Water stress during the growing season can affect the size of the harvested plant organ, and lead to soft or dehydrated fruit that is more prone to damage and decay during storage. On the other hand, vegetables experiencing an excess of water during the growing season can show a dilution of soluble solids and acids, affecting flavor and nutritional quality.

Excess moisture on the harvested vegetable can also increase the incidence of postharvest diseases. To minimize the amount of water on the harvested vegetable brought into storage, it may be beneficial to choose surface or subsurface irrigation rather than overhead irrigation. Vegetables



photo: L. Halley

Laying irrigation pipe at Harmony Valley Farm.

harvested in the early morning, during rainy periods, and from poorly ventilated areas can also experience increased postharvest decay.

## Insect Pests

Insect pest problems during the growing season can also affect postharvest quality, both in obvious and not-so obvious ways. Visible blemishes on the vegetable surface caused by insect feeding can have a negative effect on the appearance of vegetables, thus decreasing their appeal to consumers. Feeding injury on vegetables by insects can lead to surface injury and punctures, creating entry points for decay organisms and increasing the probability of postharvest diseases. In addition, the presence of insect pests on vegetables entering storage leads to the possibility of these insects proliferating in storage and becoming a chronic issue.

## Selection of Vegetable Varieties

The selection of the right vegetable variety for your farm and market channel can greatly influence the subsequent postharvest quality.<sup>3</sup> Certain varieties are more suited for the longer-term storage that is essential for marketing to larger wholesale outlets. Other varieties may optimize taste, essential for the postharvest quality of vegetables going to farmers' markets or CSAs.

When planning which vegetable varieties to grow on your farm, it is important to consider which harvest windows are needed. Vegetables harvested at the incorrect stage of maturity will have a significant decrease in postharvest quality. Quality characteristics such as texture, fiber and consistency are greatly affected by stage of maturity at harvest. Fruits and vegetables that are harvested while immature are highly susceptible to shriveling and mechanical damage. Fruits

## WHOLESALE SUCCESS Section 2: Postharvest Preparation

and vegetables harvested at an overripe stage often have poor texture and flavor. Suboptimal harvest dates lead to a greater susceptibility to postharvest physiological disorders than harvest dates closer to the proper stage of maturity.

### Other Production Considerations

Certain production techniques can also help to attain the optimal postharvest quality. These techniques include:

- Staking of tomato crops allows the fruit to remain off the ground during the growing season. By keeping the fruit off the ground, fruit blemishes and decay are minimized. This, in turn, leads to less postharvest decay in storage. Certain staking techniques also may allow more light to penetrate through the canopy,
- allowing for greater carbohydrate synthesis by the plant and thus improving fruit taste.
- Pruning certain crops (such as tomatoes) can alter the microclimate around the plants in ways that benefit postharvest quality. For instance, removing some of the plant foliage can allow for better air circulation and thus minimize excess moisture around the fruits, leading to less decay and postharvest disease issues.
- Row covers over certain vegetables can minimize damage, especially to leafy greens. By minimizing physical injury to the plant tissue, fewer entry points for microorganisms are present on the vegetable surface, thus minimizing the potential for postharvest diseases to manifest.



Photo: Martin Diffley

*Tying tomatoes, Florida Weave Method at Gardens of Eagan Farm. Basket weaving tomatoes, keeps fruit from touching the ground, reduces fruit rot and increases fruit quality.*

## Section 3: Harvesting



photo: Paul Markin

Chris Eckert of Eckert Orchards.

### Ripeness Indicators

Ensuring that crops are harvested at the appropriate maturity is important for consumer acceptance. Small-scale producers have some advantages over industrial producers in this respect. First, small-scale producers can harvest some crops earlier, when the crop is more fragile, but may command a higher premium (for example, baby greens or other “baby” vegetables). Second, crops can be harvested later than in industrial operations, ensuring a riper and more appealing product. Lastly, crops can be harvested more often, resulting in a greater output of prime produce.<sup>1</sup>

Two different definitions of maturity can be considered when judging when to harvest. The first and most straightforward definition

is how maximum ripeness is defined for a particular crop. Crop-specific definitions can be found in the USDA grade standards, or in various published “maturity indices”. An additional definition should be considered: the maturity level appropriate to the market that is being targeted. Some crops are purposefully harvested before they are fully ripe, so that by the time they reach market they will have fully matured. A crop that is harvested in this manner must be physiologically mature; or mature enough that it is capable of ripening fully after harvest. Only certain crops have this capacity. They include: apples, avocados, bananas, blueberries, cantaloupes, cherimoya, figs, guavas, kiwifruit, mangoes, papayas, pears, persimmons, quinces, stone fruits, and tomatoes. All other produce must be harvested *when it is as ripe as the consumer desires*.<sup>2</sup>

Maturity indices are commonly used to define ripeness for specific crops. These indices can include descriptive tables; size, shape, and color charts; and sizing rings. Some characteristics that are judged in these indices include the amount of time since planting, shape, size, color, texture, and sugar content.<sup>3</sup>

After selecting the maturity index that is appropriate for the crop you are harvesting, a random sample of the crop should be selected to test for maturity. Several different aspects of maturity should be evaluated, such as shape, color, and size. Harvest workers should be trained to recognize mature produce.

### Harvest Equipment and Methods

Crops can be hand-harvested or harvested by machine. Some of the best crops

# WHOLESALE SUCCESS Section 3: Harvesting

to harvest by machine are root crops, because the whole plant can be harvested at once, and the soil can cushion the crop from mechanical damage. A number of specialized machine harvesters have also been developed for larger-scale production of other crops. For example, Earthbound Farm, a major supplier of organic greens in the U.S., uses mechanical harvesters (as shown in Figure 2) to harvest spring mix and baby leaf lettuce on one of its farms.

Hand harvesting can be advantageous, though, because it allows workers to select for quality and maturity.<sup>4</sup> With hand harvesting, the produce should be placed



Photo: University of Wisconsin

Figure 1: Hand cart

## Build a Simple Hand Cart

Stooping or kneeling and crawling to harvest salad greens requires a lot of time and energy. Lifting and moving your harvest container many times as you fill it adds to the work load. One alternative is to use a salad cutter. Another alternative is to build a simple cart which allows you to sit and roll while you harvest. This is less tiring for the knees, back, hamstrings, and torso. The cart also holds your harvest container, so it rolls along with you.

For complete instructions on building this cart, go to:

<http://bse.wisc.edu/hfhp/tipsheets/html/cart.htm>



Photo: Will Daniels of Earthbound Farms

Figure 2: Ramsay Highlander Spinach/Spring Mix Mechanical Harvester

into buckets, bags, or stackable plastic crates. These could then be dumped into field bins, which are transported to the cooling and/or packing facilities. Field bins should be vented, smooth, and clean to reduce injury to the produce. Plastic bins are preferred due to their durability and smoothness, but are more expensive.<sup>5</sup>

Field packing, if possible, is the most efficient and safe way of packaging produce. Farmers who select, sort, trim, and package produce in the field will greatly reduce the chances that produce will be damaged. Soft fruits and many vegetables are particularly suited to field packing. The advantages of field packing, besides reducing damage, include a shorter time between picking and cooling and not needing a separate packing facility. The main disadvantage is the difficulty in grading and quality control. Some field-packing techniques include picking berries into berry baskets that are pre-situated in a larger box or tray, or packing leafy vegetables on a mobile packing line. Produce should be kept in the shade whenever feasible, and it is possible to begin cooling produce directly in the field if you own or construct a portable cooling unit.<sup>6</sup>

## Avoiding Damage to Produce During Harvest and Transit

Beginning with harvest, produce is handled and is therefore at risk of being injured.



Photo: Ron Doetch

Damaged produce tends to have a shorter shelf life, be more prone to disease and decay, and appeal less to consumers. Many injuries to produce that occur during harvest can be minimized by taking the proper care in handling produce.

Minimizing handling by field packing is one of the simplest ways to prevent damage, and should be considered wherever appropriate. Clippers or knives used for harvesting should be sharpened, but should have rounded, blunt tips to minimize accidental gouging of produce. Additionally, workers should remove jewelry, wear cotton gloves, and trim nails prior to harvesting.<sup>7</sup>

Keep harvested produce away from sunlight whenever possible. You can temporarily store produce under a tree or in a shaded truck bed before bringing it back to be cooled. The core temperature of produce exposed to direct sunlight can quickly reach

temperatures several degrees warmer than the ambient air.

General common sense can help to avoid many injuries. Produce should not be dropped into containers or “manhandled.” Bins should not be aggressively handled, and overfilling should be avoided.

Produce is prone to damage during transport from the fields to the packing facilities. One way this can be avoided is to make sure the roads used are graded to eliminate major bumps. Vehicles should have adequate suspension systems, and tire pressure can be reduced to provide an extra cushioning effect. Plastic bin liners can also be used on the sides of bins to protect produce.<sup>8</sup>

### Salvaging Damaged Produce

In spite of your best efforts, some produce will inevitably be damaged during or after harvest. But all is not necessarily lost; some damaged produce can be salvaged.

For some crops, such as berries, the damaged produce found during sorting or grading can be set aside to sell for processing. Damaged apples work well for apple cider. Damaged fruit and potatoes can sometimes be sold for cattle feed, although the returns after handling and transportation costs are often greatly reduced. Another potential use for damaged fruit and root crops is alcohol production.<sup>9</sup>

Finally, damaged produce can be composted – this can be especially useful for organic operations. However, it is important that the compost be managed well to ensure that there is enough heat to destroy diseased inputs. *See Section 7 for details on safe composting methods.* Burning diseased product is another alternative.

## Section 4: Cooling Produce

### Good Cooling Begins in the Field

Whether you harvest your produce by hand, machine, or some combination of the two, immediately removing field heat is the single most important step you can take in extending shelf life and maintaining a product suitable for wholesale buyers.

Cooling produce is the most important aspect of postharvest handling. Prompt and thorough cooling will help reduce respiration, and decay, and will extend the shelf life of most produce items by several days, weeks, or even months.

Before discussing the various methods of postharvest cooling, there are several steps that can greatly reduce energy costs associated with cooling. This can help smaller-scale farmers without access to certain infrastructure, to still be able to provide a salable product. These practices will increase the efficiency of standard cooling methods:



Photo: Harmony Valley Farm.

Harvesting Flowering Kale in a shaded harvest cart with a hydraulic belt harvest aid.

- Harvest frequently; every 36-48 hours is not too frequent.
- Crops should be continuously transferred from the field to cooling facilities and storage.
- Harvest early in the day, when field heat is still low. This technique is very effective, and can reduce internal temperatures by several degrees, resulting in substantial savings on electricity for cooling.
- Night temperatures are typically 15 to 20° F cooler than daytime highs. Harvest at night under lights to take advantage of this.
- Avoid exposing harvested produce to direct sun; store in the shade or on covered flatbeds for transport.

### Respiration and Produce Quality

Each crop has a different level of respiration, which is the rate at which it consumes its built up stores of energy. The higher the respiration rate, the more perishable a crop is. Therefore it is imperative that crops with higher levels of respiration be immediately cooled to their lowest safe temperature upon harvest. Proper cooling is the only way to ensure high quality and proper shelf life.

Crops with extremely high respiration rates, such as sweet corn and cantaloupe, require cooling treatments within one hour of harvest. Even crops with lower respiration levels, such as onions and sweet potatoes, should be cooled within a few hours. Respiration increases 2-3 times for every 18° F (10° C) increase in temperature. At high respiration levels, many crops also produce high levels of ethylene, which can

# WHOLESALE SUCCESS Section 4: Cooling Produce

cause other produce items stored nearby to spoil more rapidly. A general rule of thumb for moderate and high respirators is that a one-hour delay in cooling reduces a product's shelf life by one day or more.<sup>1</sup>

Growers who do not currently own or have access to cooling facilities, refrigerated storage, or refrigerated trucks will have to carefully select which crops they grow for wholesale markets. In these circumstances, the best-suited crops are low respirators such as gourds, some melons, and certain root crops. Low respiration crops have a longer shelf life and are lower maintenance.

## Half-Cooling Time

One of the most important concepts in postharvest handling is half-cooling time. This is the time required for the field temperature to drop halfway to the desired temperature. For example, corn harvested with an internal temperature of 95°F should be cooled to 32°F. The half-cooling time would be the time required to reach 63°F. Experts agree that  $\frac{7}{8}$ -cooled (87.5%) is the appropriate time to remove the produce from precooling and placed in cool storage. Getting to  $\frac{7}{8}$ -cooled generally takes three times longer than the half-cooling time. You should also occasionally calculate the  $\frac{7}{8}$  time directly, since conditions often vary during the cooling process, and it will likely not be exactly three times longer than the half-cooling time.<sup>2</sup>

**Typical cooling curve for perishable products. Cooling times are typical of room cooling for large fruit, like peaches, exposed to moderate amounts of airflow.<sup>3</sup>**

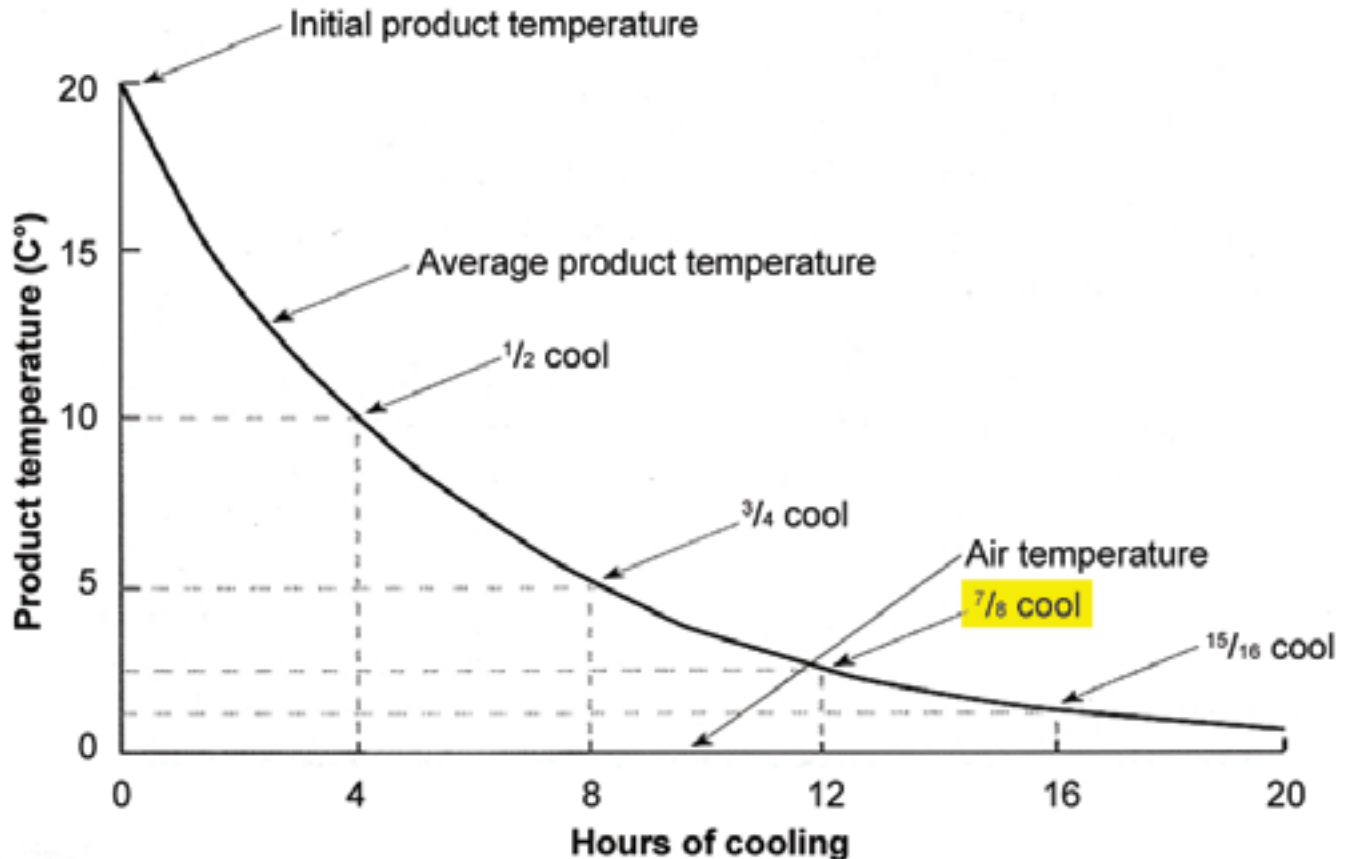


Figure 3: Half-cooling time



## Maintaining the Cold Chain<sup>4</sup>

Despite the paramount importance of removing field heat immediately, it is only the first step in a long chain of handling, packing, shipping, and delivery. Lisa Kitinoja and Adel Kader from the University of California-Davis discuss the “cold chain” from field to wholesaler. Farmers should measure and record produce and storage area temperatures at each stage until the wholesaler has picked up or received it.

### Harvest

- Protect the product from the sun.
- Transport quickly to the packinghouse.

### Cooling

- Minimize delays before cooling.
- Cool the product thoroughly as soon as possible.

### Temporary Storage

- Store the product at optimum temperature.
- Practice first-in, first-out rotation.
- Ship to market as soon as possible.

### Transport to Market

- Use refrigerated loading area, if possible.
- Cool truck before loading.
- Load pallets toward the center of the truck to minimize heat loss through the walls.
- Put insulating plastic strips inside door if the truck makes multiple stops.
- Avoid delays during transportation.
- Monitor product temperature during transport.

### Handling at Destination

- Use a refrigerated unloading area.
- Measure product temperature.
- Move product quickly to the proper storage area.
- Transport to retail markets or foodservice operations in refrigerated trucks.
- Display at proper temperature range.

Shaded areas should be available for harvested produce, cooling facilities, packing and storage areas, and transport vehicles. Trees not only provide shade in the field, but also can drastically reduce ambient temperatures around packinghouses and storehouses. Also, lighting options should be evaluated; incandescent bulbs are in fact better suited for small-scale heating purposes than for lighting a cooled storage room. Look for fluorescent or high-pressure sodium lights, which produce far less heat and require less energy to provide the same amount of light as incandescent bulbs. Higher up-front costs will save money over the medium and long-term. Make sure to shield bulbs so that if they break, glass shards will not contaminate any produce.

## COOLING METHODS

Before transporting produce into refrigerated storage, it is important to remove field heat as quickly as possible. Several methods are available to do so, depending on the item's characteristics. They include the following:

1. Room cooling
2. Forced-air cooling
3. Hydro-cooling
4. Icing
5. Evaporative cooling
6. Night-air cooling

"Prompt cooling to required temperatures inhibits growth of decay-producing microorganisms, restricts enzymatic and respiratory activity, inhibits water loss, and reduces ethylene production by the product"<sup>5</sup>

### Room Cooling

Room cooling is not a true precooling method, but uses the ambient temperature of a refrigerated storage facility to act as the cooling process. The University of Maryland Extension office defines room cooling as a cold room where air movement equals 200-400 feet (60-120 m) per minute or less through the containers.<sup>6</sup>

Because half-cooling times generally run from 12-36 hours, room cooling is an impractical choice for any moderately or highly perishable good. Most produce suffers a significant loss in quality during this time, and cooling rates will vary widely between containers. If produce is distributed properly, room cooling can be a cheap and effective method of storing less perishable items such as potatoes, gourds, onions, and some citrus fruits. To ensure equal cooling, leave adequate space between stacks of boxes for good airflow, and monitor the temperature at several

points throughout the room, including within piles or stacks of produce where cooling will likely occur more slowly.<sup>7</sup>

### Forced-Air Cooling

Forced-air cooling is similar to room cooling but adds fans to facilitate air movement through stacks of produce. This method is much faster and more consistent than standard room cooling; half-cooling times are often less than one hour. Forced-air units are also generally inexpensive and fairly easy to construct on site.

In a typical forced-air cooling setup, pallets are stacked and lined up in front of a pressure fan and covered with a tarp or other airtight covering. The tarp creates a tunnel and cold air is pulled through the pallets and through the containers.

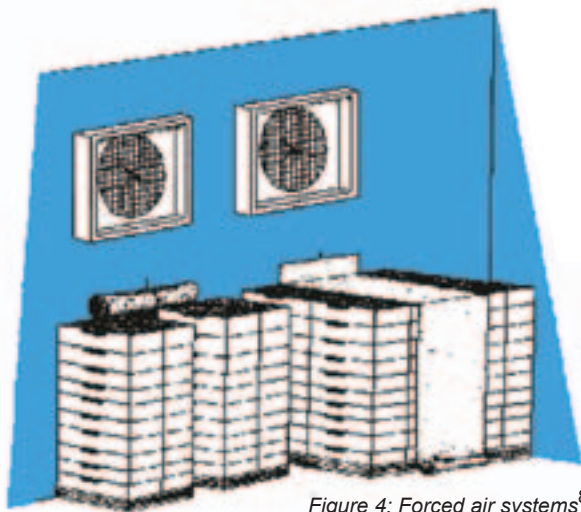
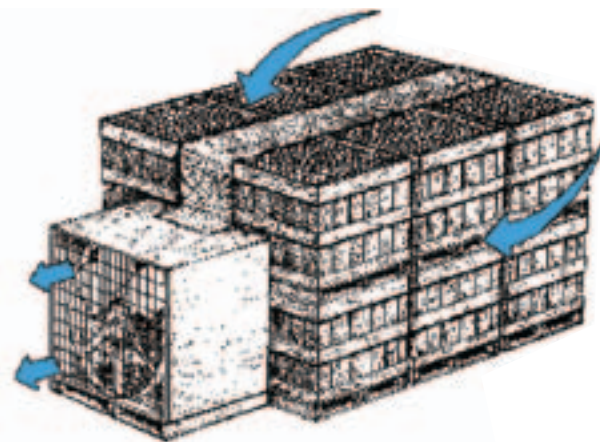


Figure 4: Forced air systems<sup>8</sup>

## WHOLESALE SUCCESS Section 4: Cooling Produce

An effective and efficient forced-air system requires packaging with vents and a fan system capable of moving enough air to rapidly cool the produce (usually 1-2 cubic feet per minute per pound).

**Because moving air also facilitates moisture evaporation, steps may need to be taken to avoid wilting, shriveling, and shrinkage.**

There are a number of approaches to keep the relative humidity in the 90-100% range required by most produce items:

- Install larger condenser coils and limit the temperature drop across the coils to 5°F or less. This will also help prevent refrigeration coils from freezing.
- Install a humidifying system.
- Do not allow condensation from the coils to drain to the outside.
- Periodically hose down the floors with cold water.
- Monitor relative humidity using a wet-bulb and dry-bulb thermometer.

Forced-air units are ideal for berries, stone fruits, fruit-like vegetables, tubers, and cole crops, though most fruit and vegetables can be cooled using forced-air.<sup>9</sup>

Do not blow air at the storage containers, but orient the fans so that they pull air over the produce and through the boxes of produce. Blowing air at the produce can “short-circuit” the airflow, with air going immediately back out the fan without reaching the containers. Ideally, there should be a separate room dedicated to forced-air cooling, but you can cheaply integrate it into a storage room by hanging a tarp from the ceiling or installing a second wall.<sup>10</sup>

For crops with extremely high respiration rates, forced-air cooling may not be the most appropriate choice, since it will not cool produce quickly enough to maximize shelf life or even prevent decay. It is possible to combine high airflow with high relative humidity and mist the produce before cooling in order to make forced-air cooling appropriate for these crops.

The graph in Figure 5 below illustrates how much more effective forced-air cooling can be versus room cooling. Curve A represents the comparatively slow rate of cooling that can be expected without forced air movement (i.e., room cooling only). Curves B and C demonstrate the increase in cooling rate possible with airflow rates of 1/2 and 1 cubic foot per minute per pound of produce, respectively.

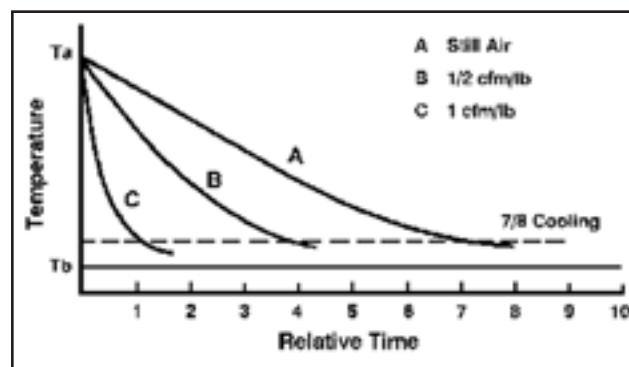


Figure 5: Rate of cooling chart<sup>11</sup>

The formula for how much refrigeration is needed at any given moment can be calculated as follows:

$$(Btu/hr) = 2.1 \times (A - B) \times C \times D \div E$$

Where:

A = Temperature of produce, °F (°C)

B = Temperature of cooling air, °F (°C)

C = Weight of produce being cooled, in lb. (kg)

D = Specific heat of produce, usually about 0.9 Btu/lb./°F (3.77 kJ/kg/°C)

E = 7/8 cooling time (hr)

For the initial stages of refrigeration, this equation will produce very high refrigeration amounts, often over 20 tons. A general rule

of thumb is to design for  $\frac{2}{3}$  of the amount of refrigeration required at the beginning of pre-cooling.

### Hydro-Cooling

Hydro-cooling takes advantage of water's ability to rapidly transport heat away from an object. While hydro-cooling is one of the fastest and most uniform pre cooling methods available, it is also moderately expensive to set up properly, not appropriate for many crops, and can quickly distribute pathogens if the water has not been properly sanitized. Hydro-cooling is generally best suited for leafy greens, cole crops, some fruit-like vegetables, stone fruits, and some root crops. It should be avoided for crops that cannot tolerate exposure to high levels of water or chlorine.

Hydro-cooling can be performed either by spraying or immersing the product in cold water. The simplest form of hydro-cooling is dipping produce into a tank of cold water. This is the type of cooling used on many smaller farms. The water is either chilled with ice or comes from cold water wells. With these immersion systems you can add ice to keep the water cool or have some type of additional cooling boost to maintain proper water temperature. It is important to ensure that the water used is free of pathogens by using a water sanitizer.

In spraying systems, refrigeration is required to maintain a water temperature of approximately 33°F (1°C), though the temperature will fluctuate initially as produce is inserted into the water. Moving water cools items more quickly, and an efficient rate for spraying is 10-15 gallons per minute per square foot. For conveyor systems, water should move at 20 feet per minute. Water should be recycled whenever possible, though it should be changed daily as the amount of dirt and bacteria increases. If there is a particularly high dirt/

debris load, more frequent changing may be necessary.<sup>12</sup>

One notable downside of hydro-cooling is energy efficiency. Because water often comes into contact with several surfaces and the air, up to one-half of the total cooling capacity can be lost to the surroundings. This holds true for most homemade and many commercial hydro-coolers.

Energy use in hydro-coolers may be substantially reduced by:<sup>13</sup>

- Using generous amounts of insulation on all refrigerated surfaces and positioning the hydro-cooler out of the wind and sunlight.
- Using plastic strips on both the inlet and outlet ends of conveyor hydro-coolers to reduce the water-to-air heat gain.
- Operating the hydro-cooler at maximum capacity. Intermittent operation wastes energy, as does operation at reduced capacity. A low-capacity hydro-cooler operated for long periods is more energy-efficient and economical than a high-capacity unit operated for shorter periods. Some hydro-coolers may now be purchased with a thermal storage option. Thermal storage capacity not only reduces the size of the refrigeration unit necessary, but may also result in a smaller energy bill.
- Using an appropriate-sized water reservoir. An oversized water reservoir wastes energy because the remaining cooling capacity of the water is lost when it is dumped at the end of the day.

### Sanitation

Hydro-cooling creates an opportunity for water-borne pathogens to reproduce readily. Additionally, because postharvest pathogens travel quickly in the water, there

## WHOLESALE SUCCESS Section 4: Cooling Produce

is the potential for contamination of an entire load of produce. Peroxyacetic acid is a good substance for sanitizing water. Chlorine is an accepted disinfectant for hydro-cooling water, but is subject to federal law and must be carefully monitored.

Peroxyacetic acid or chlorine can be used to sterilize water used for hydro-cooling. Many farmers consider chlorine hazardous because of its toxic fumes and, as a result, more are using peroxyacetic acid. Any farmer discharging water, such as from a hydro-cooler, must comply with the Safe Drinking Water Act. Chlorine concentrations at the discharge/effluent point may not exceed the Maximum Residual Disinfectant Limit (MRDL) of 4mg/L for chlorine and 0.8mg/L for chlorine dioxide. Chlorine is allowed in organic production, as long as it remains within these limits. However, individual certification agencies may have more stringent regulations regarding the use of chlorine. Contact your certifier to ensure that you do not accidentally jeopardize your organic status. Chlorine materials may also be used to sanitize food contact surfaces but, again, the residual chlorine levels in the discharge water may not exceed the MRDL.

When using chlorine, measure the pH of the water before and after adding it. Chlorine is most effective in neutral water (pH = 7.0). When water is either acidic (pH < 6.5) or basic (pH > 7.5), much more chlorine is needed to act as a disinfectant. In water with a pH of 8.5, seven times as much chlorine must be added as for water with a pH of 7.0. Hypochlorites will cause the water to become more basic (i.e., have a higher pH), so the addition of some acids may be required. Common acids such as lemon juice or vinegar will work. On the other hand, making the water too acidic can result in the formation of chlorine gas, which is toxic. Certified organic operations should

check the approved materials list to make sure that the particular acid is allowed.

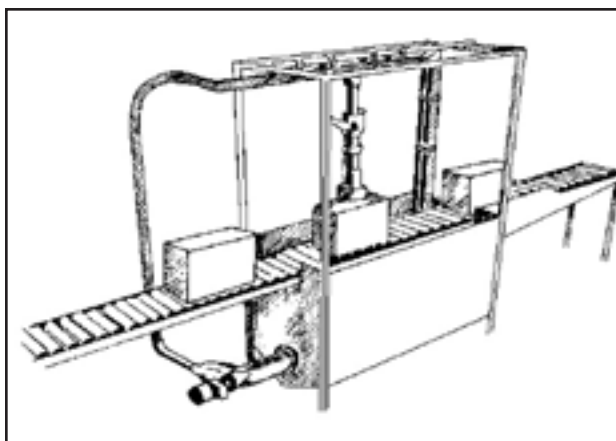


photo: Atina Diddle, Gardens of Eagan Farm

*Small to mid-size growers can use a crushed ice machine to manually ice boxes of produce prior to stacking them on pallets.*

### Package Icing (crushed/liquid)<sup>14</sup>

Package icing incorporates crushed ice and/or ice-slurry to conveniently maintain a water temperature around 32°F (0°C) without adding a refrigeration component to the system. It is simple, inexpensive, and provides uniform pre-cooling. This can be automated for single packages on a conveyor belt, done manually, or automated for an entire pallet. Figure 6 illustrates an automated single-package system, which minimizes slurry exposure to the air and warm surfaces while making sure that it comes into contact with all parts of the produce.



*Figure 6: Liquid icing single cartons of produce.<sup>15</sup>*

## WHOLESALE SUCCESS Section 4: Cooling Produce

For produce that has already been palletized, you can use hoses to manually fill the boxes through their hand openings. NCSU Extension estimates that two workers can fill a pallet of 30 cartons (3x2x5) in 5 minutes.<sup>16</sup> Like many manual postharvest practices, this method involves repetitive motion and could lead to injury over a period of time.

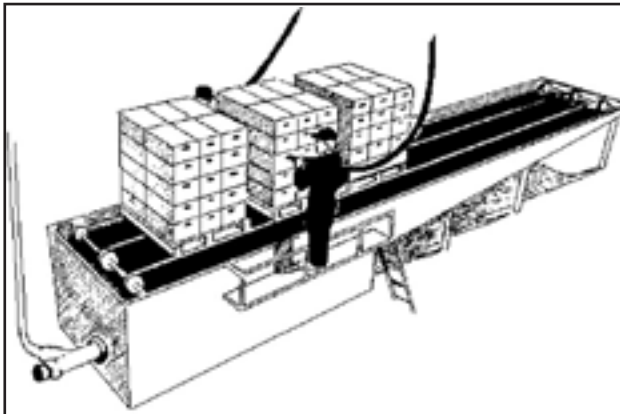


Figure 7: Injecting liquid ice into palletized broccoli cartons through the hand openings.<sup>17</sup>

The third method, seen in Figure 8, is fully automated, and can be operated by the truck operator alone. A full pallet is placed in an enclosure that is rapidly filled with ice slurry. The excess slurry is then drained away, and the cartons are left filled with small flakes of ice. These may be somewhat costly.

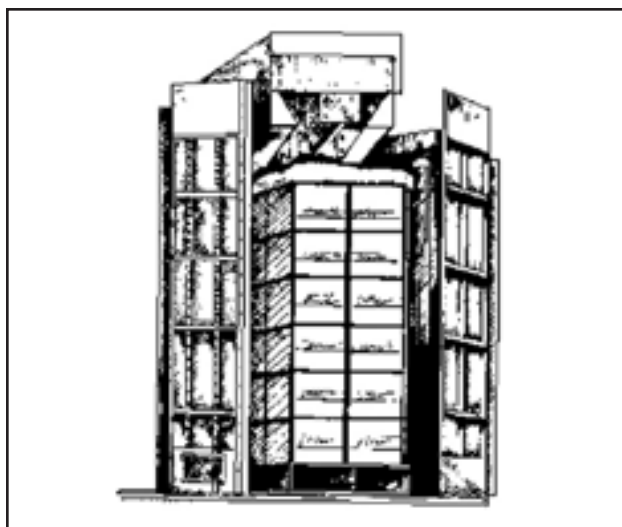


Figure 8: Automated pallet icing.<sup>18</sup>

The amount of ice slurry needed to cool produce can be calculated by weight and desired temperature loss. For example, cooling produce from 95°F (35°C) to 3°F (2°C) requires ice equal to 38% of the weight of the product. Inefficiencies along the line, such as poor insulation, heat loss to the ambient air, warm trucks, etc., can increase this amount to 75% or higher.<sup>19</sup>

To calculate how much ice will be needed, you need to know the following: the specific heat of the produce involved, the initial core temperature of the produce and desired storage temperature, the fact that one pound of ice will absorb 144 Btu of heat, and whether you are using package icing or liquid icing (ice slurry).

Specific heat is the amount of energy required to lower one pound of produce by 1 degree Fahrenheit (or 1 kilogram by 1 degree Celsius).

As an example, a 20-pound box of broccoli is harvested at a core temperature of 85°F. Broccoli, like many fruits and vegetables, has a specific heat of 0.92. This means that .92 Btu will lower the temperature of 1 pound of broccoli by 1°F every hour. The optimal storage temperature for broccoli is 32°F, and since pre-cooling should account for  $\frac{7}{8}$  of the total cooling, broccoli with a core temperature of 85°F should be cooled with the ice slurry to 38°F. To lower the temperature of broccoli by 85° - 38° = 47°F requires  $20 \text{ (lb)} \times 47 \text{ (F)} \times .9 \text{ (specific heat)} = 846 \text{ Btu}$ . Under ideal conditions, with no energy loss to ambient air and surfaces other than the produce, you would only need  $846/144 = 5.86$  pounds of ice. In reality, though, a large portion of the ice melts in response to heat entering from outside the carton and contact with surfaces other than the produce. Reasonably assuming that 1,000 Btu of heat enters from the outside, the amount

of ice needed then becomes  $1,846/144 = 12.82$  pounds. You should round up by a few pounds to allow for any extraordinary conditions, such as a defective refrigeration unit during shipping, more energy loss to the ambient air than expected, or other similar problems.

Liquid icing or ice slurry has even higher ice needs in order to keep the water at a low temperature. For a 20-pound carton, an additional 10 pounds of ice are required, bringing the total to 25 pounds of ice for a 20-pound carton of broccoli.

For growers producing high volumes, a hydro-cooler may be a more cost-effective option.

Icing is used for dark leafy greens such as kale, spinach, and collards, root crops such as radishes and carrots, cantaloupe, and green onions. Top icing is ideal for sweet corn, celery, and other leafy vegetables.

Icing is limited to commodities that can withstand water-ice contact. Water-tolerant shipping containers are also needed.

Finally, packing ice, like any water-based cooling system, can spread pathogens. To minimize food safety concerns ensure ice is made from potable water sources only (with sanitizer added if necessary) and that ice making equipment is sanitized to prevent the spread of bacteria.

## Evaporative Cooling

Evaporative cooling is similar to forced-air cooling, but uses a wet, gas-permeable membrane instead of a refrigeration unit to cool the intake air. Evaporative cooling can reduce core temperature by 10 to 15°F, and a fan re-distributes the cooled air through the stacks of produce.<sup>20</sup>

Evaporative cooling setups can be built into forced-air coolers to lighten the load on the refrigeration unit while also helping maintain a high relative humidity.

## Night-Air Ventilation

Night-air ventilation is a very low-tech approach to pre-cooling produce. As the name suggests, night air ventilation takes advantage of the relatively cooler temperatures during nighttime hours to remove field heat. A well-insulated building is equipped with ground level vents and gable fans in the upper portions of the building. When the fan blows air out of the building, the resulting vacuum pulls cooler outdoor air in through the ground vents. During the day, the vents are closed and, provided there is appropriate insulation and a reflective roof, the building remains relatively cool during the day. This is very appropriate for items that are sensitive to chilling-injury, have low respiration rates, are not very perishable, and that should be stored at 50-60°F (10-16°C).<sup>21</sup> To ensure cooler daytime temperatures, it is wise to situate the building among trees and greenery, not only because of shade but because the plants will reduce ambient air temperature by several degrees. With the possibility of hot summer nights in some regions, it may not be wise to rely on night-air cooling for crops that need rapid cooling.

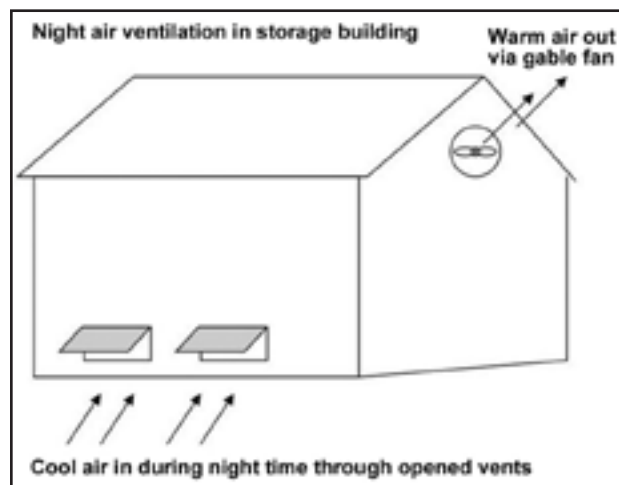


Figure 9: Night air ventilation.<sup>22</sup>

## Section 5: Cleaning, Packing, and Sorting

### Cleaning<sup>1</sup>

There are several different approaches to cleaning produce, depending on the type of produce.

#### *Washing*

Crops that should be washed include green beans, bananas, peppers, greens, cucumbers, carrots, potatoes, papayas and truffles, as well as many others. Most crops should be cleaned before cooling and storage, but potatoes and root crops are better off being cleaned after storage. Washing systems differ, but they all include a continuous flow of fresh water. Sanitation of the water is essential. This is often achieved by using chlorine or Peroxyacetic treatments, and keeping the pH of the water between 6.5 and 7.5. Water should be kept cold except where there is the potential for internalization of microorganisms from the water into the produce. This is a risk for tomatoes, for example; if they must be washed the wash water temperature should be kept around 50 F (10 C). Sponges or wet brushes can be used during washing; peaches in particular should be wet-brushed to remove fuzz. Water remaining on the produce after washing should be removed using sponge rollers or air flow.

#### *Types of Washers*

**Barrel Washer** – Barrel Washers use water and a gentle tumbling action to remove the surface membrane of root vegetables and polish them.

#### **Salad or Baby Greens Spinner** –

Commercial salad spinners or even the spin cycle of old washing machines are a great way to clean greens. You can soak them in cold water with a sanitizer and then spin

them dry. Many farmers double wash the greens to ensure that they are fully cleaned. Some farmers put greens in a mesh bag for ease of handling.

**Pressure Washer** – A pressure washer provides a strong stream of water to clean soil off of sturdy fruits and vegetables.



Photo: Michael Fields Agricultural Institute

#### *Dry brush*

Some crops simply need to be dry-brushed after storage or after curing. These include onions, ginger, garlic, and melons.

#### *Don't wash*

Some crops don't need washing at all; washing can cause unnecessary damage to fragile crops or crops sensitive to decay on wet spots. These include tomatoes, figs, mature coconuts, mushrooms, cabbage, okra, summer squash, berries, and peas.

### Presorting Produce

Produce should be sorted through to remove damaged, diseased or decayed produce before cleaning, cooling, and storing. By removing these elements early on, much spread of disease and decay can be prevented. Presorting is especially important for organic operations, because



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## Hands-Free Washer<sup>3</sup>

For under \$50, you can make a simple sprayer that does not need to be held or squeezed by hand. With both hands free, you can process produce faster and more efficiently with less strain on your body.

### Benefits of using fixed sprayers:

**Less stress on the body.** A hands-free washer allows you to wash the produce comfortably and efficiently. For most right-handed workers, this means moving the produce through the stream from your left hand to your right. Since you eliminate the need to hold, squeeze and direct the hose, your hands and arms are less likely to fatigue.

**Faster.** Using a hands-free washer can be nearly 40% faster than using a hose and nozzle. Faster washing means higher quality produce and savings in labor time.

**Less damage to crop.** You can choose a nozzle with the right spray pattern for your job. For example, use a strong spray for roots and a gentle spray for leafy greens.

### How do I build one?

All the parts you need to build your own hands-free washer are available through plumbing, irrigation or hardware stores. Check the yellow pages or try the following:

Hummert Int'l                      Waldo and Associates  
800-325-3055                      419-666-3662

[www.hummert.com](http://www.hummert.com)

These references are provided as a convenience for our readers, not as an endorsement.

[http://bse.wisc.edu/hfhp/tipsheets\\_pdf/hndsfree4web.pdf](http://bse.wisc.edu/hfhp/tipsheets_pdf/hndsfree4web.pdf)

many chemical treatments cannot be used to prevent disease or pests in storage or packing.<sup>2</sup>

## Packing Area Design<sup>4</sup>

Setting up an efficient packing area can save money, increase safety for workers, and result in better handling of produce. The first step is to diagram your current packing area and then to look for inefficiencies. Is the space large enough? Are there uncluttered paths for workers to follow? Do the paths intersect with each other, increasing the risk of collisions? Are water and electricity available at convenient locations? An example of efficient and inefficient designs is shown below.

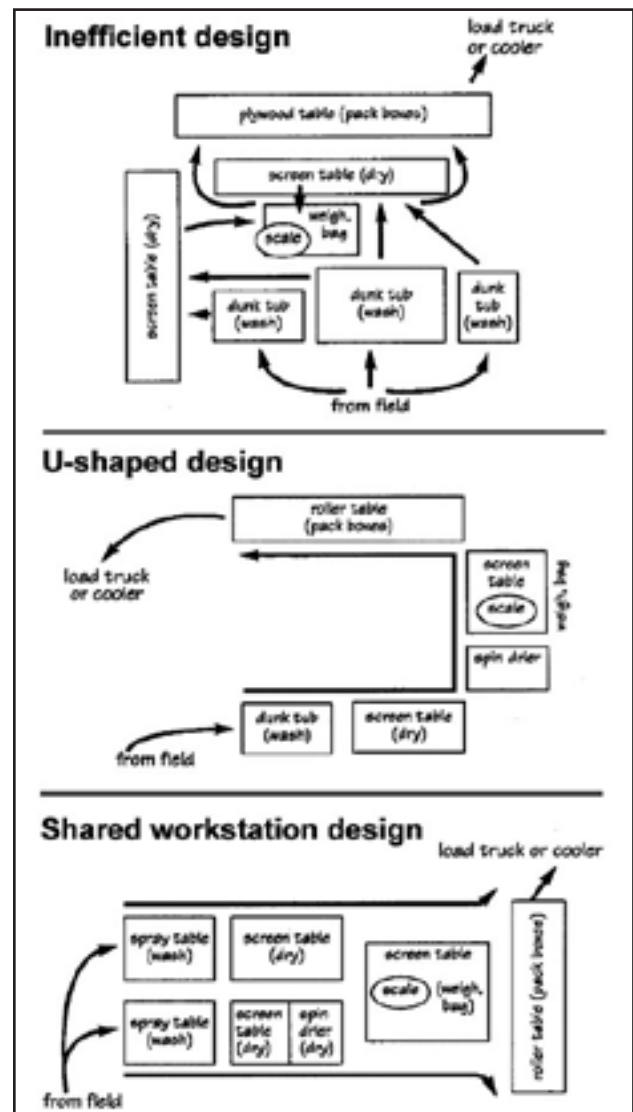


Figure 10: Packing area designs.<sup>5</sup>

# WHOLESALE SUCCESS Section 5: Cleaning, Packing and Sorting

Besides efficient flow and placement in the packing area, there are other considerations that can make the area safer and more efficient.

- There should be enough lighting.
- The floor should be smooth; concrete is best, followed by asphalt. Wood chips or dirt are rough and unsanitary.
- Wash-water tubs should be easily drained away from the work area.
- Worker comfort should be considered. There should be adequate shade; workstation heights should be comfortable – adjustable heights are best; step stools or chairs could be provided.
- Surfaces should be easy to sanitize.
- Supplies should be kept where needed; other items should be kept out of the way.
- Electrical outlets should have Ground Fault Circuit Interrupters. These can prevent electrocution.

## USDA Grade Standards

The Agricultural Marketing Service branch of the USDA maintains a complete list of US Grade Standards for fruits and vegetables. These grades categorize produce based on characteristics such as shape, size, color, damage, and freshness, among others. Most common produce items have both No. 1/Fancy and No. 2/Commercial grades. The primary difference between the two groups is visual appearance and the specified tolerance for damage or decay. Produce with No. 1 and Fancy grades are generally sold to buyers who will display it directly to consumers – primarily grocery stores and food retail outlets. No. 2 and Commercial grade produce is usually processed and goes to foodservice buyers, including

restaurants, institutions, and processed foods producers.

Wholesale buyers will adhere to US Grade Standards and require that suppliers sort and package their produce accordingly. Some wholesalers may have more stringent requirements, particularly in regard to visual appearance. Certain types of produce are sorted by weight, others by length or size. See the crop profiles for details on how to properly sort your produce. Adhering to uniform grade, sorting, and packing standards will help you precisely calculate your crop yields and keep track of production from year to year. Wholesale buyers will want to know this information when you are planning with them for the coming year.

Wholesale buyers will prefer suppliers who ship predictable and consistent quality product. The picture below illustrates examples of correct and incorrect packaging. You can earn the trust of your wholesaler by following the guidelines.



Photo: Dennis Fiser

Wrong and right way to pack peppers

## WHOLESALE SUCCESS Section 5: Cleaning, Packing and Sorting

The crop profiles in this manual include summaries of the USDA Quality Standards. Full-text versions are available for free online at: [www.ams.usda.gov/standards/stanfrfv.htm](http://www.ams.usda.gov/standards/stanfrfv.htm).

Unlike direct marketing, where consumers are specifically looking for produce based on qualities such as flavor, selling to the wholesale market first and foremost requires produce that has been properly handled and sorted. Wholesalers expect and demand consistent quantity, quality, packaging, and handling. While buyers may have their own preferences, there are de facto package standards in the wholesale industry. These package weights and sizes are included in the crop profiles found toward the end of this guide. Conforming to USDA quality standards is a must, as is appropriately sorting produce, either by size or by weight.

You may have to alter your production practices to receive the higher USDA grade, but both U.S. No. 1 and No. 2 are very salable and profitable. Properly grading your produce will help you to maximize revenue while minimizing the amount of product that would otherwise get plowed under or composted. Wholesale buyers will be able to quickly and efficiently sell your product, independent of the grade.

Another aspect of uniformity, often overlooked, is that produce must not only be of a consistent quality and quantity, but must be consistently available *for a period of time*. In order to secure shelf space in retail outlets, stores need to know that produce will be arriving as the existing supply is sold.

It is important to be able to tell your wholesaler how much you expect to grow in the following year. By using standard packaging during the postharvest process, you can readily calculate total harvest by weight, count, and volume. Other

advantages of using standard-size packages is that they are stackable and easy to transport via dolly or truck, and will fit with other containers in the wholesaler's storage areas. Options for packing are presented in *Section 8: Crop Profiles*.



Photo: Jim Stama

Lady Moon Farms

### Sorting Equipment and Techniques<sup>6</sup>

Sorting for size can be done in several different ways, both through hand-sorting and mechanical sorting.

#### Mechanical sorting

Mechanical sorting ranges from high-tech video imaging systems, to handmade sizing tables. The more high-tech systems are generally only cost effective to the largest of operations.

A sizing table can sort round produce into different sizes. The table consists of a series of stacked tables with many holes cut in each table. The top table has the largest holes, and the bottom table the smallest. Produce is dumped onto the table, and will filter through (by shaking the table or moving produce by hand). The resulting layers will each hold produce of uniform size, with the smallest size on the bottom, and the largest on top. Care should be taken to handle produce with care – layers of the table shouldn't be too far apart, and under

## WHOLESALE SUCCESS Section 5: Cleaning, Packing and Sorting

the bottom layer a net or padded container should catch the smallest produce.

Another method of mechanical sorting is the divergent bars method. This involves having a set of bars that fan out from each other. Produce is rolled along the bars, starting at the smaller end. As the bars fan out from each other, larger and larger produce will start falling between the bars. Containers should be placed beneath the bars (but not too far, so as to minimize damage) at different points to catch the subsequently larger sizes of produce.



Photo: Dennis Nolan

*Atina Diffley packing peppers at Gardens of Eagan Farms*

### Hand Sorting

Hand sorting is the most common method for smaller operations. For the most part, sizing is done visually. Workers should be trained to recognize the proper sizes, and should be provided sizing rings or examples of different sizes to refer to as needed. This sorting can occur separately from packing, or as produce is being packed. Conveyor belts are useful for maximizing the efficiency of the sorting process.

### Standard Packaging Sizes and Types<sup>7</sup>

Most containers of packaged produce are hand-lifted at some point, and should therefore be of a reasonable weight (not

more than 44 lb. in most cases). Boxes are generally arranged on pallets, and so should be of certain dimensions to maximize the number of boxes per pallet. Pallets are usually 48" x 40". The standard sizes for boxes to fit on pallets (and the number of boxes of a size that will fit on a pallet) are: 19" x 13.3" (9 boxes), 20" x 12" (8 boxes), 20" x 16" (6 boxes), 24" x 16" (5 boxes), and 24" x 12" (4 boxes). Most produce can be packed in one of these sizes of boxes. It is important not to overfill the boxes, since this can cause the sides to bulge, making it difficult to fit the estimated number of boxes on a pallet and potentially resulting in damaged produce.



Photo: Jim Slama

*Lady Moon Farms*

Wood, plastic, and plastic-foam containers are generally used for storage and stand up well to moisture. Root crops can be packaged in fabric or plastic bags, although they are more prone to damage.

For final packaging, corrugated cardboard or fiberboard boxes or wooden crates are most commonly used. Containers can be volume-filled, or many different containers

## WHOLESALE SUCCESS Section 5: Cleaning, Packing and Sorting

can be used within the outer container. For example, clamshell containers or fruit trays can be layered within each box.

For crop-specific container sizes and types, refer to *Section 8: Crop Profiles*.



Photo: Jim Slama

Lady Moon Farms

### How To Pack

For many crops, it is important to select containers that do not break down when exposed to water. Waxed cardboard or other treated containers work well. Perforated polyethylene liners in boxes are often used for produce susceptible to dehydration. The liners allow excess water to drain from the produce, while still somewhat insulating the produce from excess water loss.

Produce that is tolerant to icing (i.e., produce that isn't sensitive to chilling-injury and can handle being wet) can be package-iced. Some crops, such as broccoli, can be package-iced without any barrier between the ice and the broccoli. For others, such as some leafy greens, a sheet of paper should

be placed between the ice and the produce. Top icing is also useful for maintaining low temperatures during transport. Top icing involves covering containers with ice.

Proper ventilation is essential for packaging to maintain cooling in storage or during shipping. Most containers will have vents for this purpose, and even perforated liners generally provide enough ventilation (However, unperforated liners do not allow proper ventilation). When containers are stacked together, care should be taken to line the vents up so that they create a "tunnel" effect, and are not positioned in ways that block the vents.

Produce should not be packed too tightly or too loosely in containers. Either extreme can cause bruising or injury – whether from overcompression or from loose produce bouncing around. Paper or tissue can be used to cushion produce that is otherwise packed too loosely. Some packing densities for produce, along with recommended container sizes, are listed in the individual crop profiles in Section 8.

### Storage

#### Temperature and Humidity<sup>8</sup>

Proper cooling and refrigeration is essential for prolonging the shelf life of produce. Refrigeration slows the spread of disease and decay. Recommended temperatures vary by crop; specific temperatures are listed in the crop profiles. However, many crops are stored close to 32°F (0°C). To avoid chilling-injury, temperature should never vary more than one degree in either direction. However, this level of precision may be difficult to achieve. At a minimum, make sure you set the temperature to a level where the temperature will never fluctuate *too low*, resulting in chilling-injury.

Cooling systems should be well designed to maximize effectiveness. The cooling system should be large enough to handle the maximum heat load expected, but not so large that the extra capacity is wasted. There should be an air circulation system to mix the cooled air with the room air, but the circulation should be slow to avoid drying out the produce. Cooling systems should be specially designed to work with high humidity levels, otherwise the temperature readings may not be correct.

Recommended humidity levels also vary by crop, but most are in the 90-100% range. Humidity below this level can result in detrimental moisture loss; however it should be noted that humidity around 100% could exacerbate the growth of molds or other diseases. Humidity can be controlled through several methods, such as mechanical humidifiers or fog spray nozzles. It should be noted that higher levels of humidity will result in the need for frequent defrosting of the refrigeration coils.

Refrigerated trucks are the most common method of transportation for produce that must remain cooled during shipping. Produce should be loaded making sure to leave space near the walls; contact with walls can warm the produce to unacceptable levels, especially in hot weather. Cool air is generally dispersed from the top of the trailer, and less frequently from the bottom. Bottom-delivery of cooled air can have the capacity to cool warm produce, but with top delivery the produce will need to be pre-cooled prior to shipping. Humidity is rarely controlled during shipping, but atomizers are sometimes used.

### **Shelf Life**

Many factors combine to determine the shelf life of produce. High quality produce has the longest shelf life. It is important to

remember that the quality of produce at the time of harvest can only be maintained; it cannot be improved. Additionally, produce that is harvested at optimum maturity will last longer in storage.

Cut or bruised produce will have a shorter shelf life, because it will decay faster and be more susceptible to disease. Maintaining an optimal storage temperature, often close to 32°F, is essential for slowing the rate of deterioration. Proper refrigeration can dramatically extend the shelf life. A proper humidity level helps prevent water loss and therefore also helps produce stay in optimum shape longer. Controlled atmosphere in storage is also appropriate to prolong the shelf life of certain fruits and vegetables.

### **Respiration Rates**

Despite having been detached from the plant, fruits and vegetables remain as living organs after harvest. Like all living tissues, harvested produce continues to respire throughout its postharvest life. During the process of *respiration*, carbohydrates are broken down to their constituent parts to produce energy to run cellular processes, thus keeping the cells and organism alive. Throughout this process, oxygen is consumed, while water, carbon dioxide, and energy are released. Because this process occurs from harvest to table, the carbohydrates stored in the harvested plant portion are continually “burned” as energy to keep the vegetable alive; as respiration continues, compounds that affect plant flavor, sweetness, weight, turgor (water content), and nutritional value are lost. Thus, reducing the rate of respiration is an important consideration in extending the postharvest life of a commodity and optimizing postharvest quality. Harvested organs of different plants have different rates

## Classification of Sample Horticultural Commodities According to Respiration Rates<sup>9</sup>

Class	Commodity
Very Low	Dried fruits, nuts
Low	Apples, garlic, grapes, onions, potatoes (mature), sweet potatoes
Moderate	Apricots, cabbages, carrots, figs (fresh), lettuce, nectarines peaches, pears, peppers, plums, potatoes (immature), tomatoes
High	Artichokes, brussels sprouts, cut flowers, green onions, snap beans
Extremely High	Asparagus, broccoli, mushrooms, peas, sweet corn

of respiration; some respire at a faster rate (and thus are more perishable vegetables), while some respire at a relatively slow rate (less perishable vegetables) (see table above). In addition, storage conditions affect respiration, with higher temperatures leading to a faster rate of respiration. For every 10°C rise in temperature, the respiration rate will double or even triple. Because of the significant effect of temperature on respiration, the amount of time a harvested product is exposed to heat should be minimized, with the commodity quickly brought to its optimal storage temperature.

### Ethylene and Its Effects on Postharvest Handling

Ethylene is a colorless gas that is naturally produced by plants and functions as a plant growth regulator. In this way, ethylene behaves in the same way as hormones in mammals; it triggers specific events during a plant's natural course of growth and development, such as ripening. Through this action, it induces changes in certain plant organs, such as textural changes, color changes, and tissue degradation. Some of these changes may be desirable qualities associated with ripening; in other cases, ethylene can cause damage or premature decay. Fruits and vegetables may be classified depending on their response to ethylene. *Climacteric* species increase ethylene production as they ripen, and the

harvested produce is capable of ripening during the postharvest period. These commodities, such as bananas, apples, and peaches, tend to get sweeter and softer after harvest. *Nonclimacteric* plants, such as leafy vegetables do not continue to ripen after harvest; they will soften and rot, but this is due to moisture loss, decay, and tissue deterioration.

In addition to being naturally produced by plants, ethylene is produced by a variety of other sources. These include internal combustion engines, cigarette smoke, and natural gas leaks. Even low concentrations of ethylene throughout the postharvest life of a commodity can affect quality, so care must be taken to minimize exposure to both natural sources (i.e. climacteric fruit or veggies being stored with nonclimacteric ones) and to artificial sources (engine exhaust, heaters, etc). All ethylene-producing sources should be considered when optimizing postharvest storage conditions, since inadvertent exposure to ethylene can contribute to loss of quality in certain harvested commodities.

Examples include:<sup>10</sup>

- russet spotting of lettuce (dark-brown spotting on the mid-ribs of lettuce leaves)
- yellowing or loss of green color (e.g., in cucumber, broccoli, kale, spinach, and acorn squash)
- increased toughness in turnips and asparagus spears

- sprouting in potatoes
- yellowing and abscission (dropping) of leaves in Brassicas
- softening, pitting, and development of off-flavor in peppers, summer squash, and watermelons
- browning and discoloration in eggplant pulp and seed
- discoloration and off-flavor in sweet potatoes
- increased ripening and softening of mature green tomatoes
- development of bitter taste in carrots and parsnips

In order to reduce ethylene exposure during storage, the following steps can be taken:<sup>11</sup>

- Not storing or transport green leafy vegetables in containers holding ripening fruit (i.e., apples, pears, mangoes, tomatoes, and bananas)
- Storing or transporting at the lowest safe temperature; less ethylene is produced than at warmer temperatures, and produce is less sensitive to ethylene at lower storage temperatures
- When possible, using electric powered equipment in storage areas versus gas powered
- Removing overripe or rotting fruit from storage loads (these produce higher amounts of ethylene)
- Avoiding storing ethylene-sensitive products with products that produce high levels of ethylene
- Increasing the ventilation rate of the storage area, assuming that the outside air is ethylene-free
- Using ethylene scrubbers in storage areas to remove ethylene in the air

## Air Composition

Controlled atmosphere (CA) can help to reduce decay and extend the shelf life of many types of produce. This generally involves having a gas-tight storage room, reducing the amount of oxygen in the air, and increasing carbon dioxide. While there are clear benefits to properly implemented CA, if the ratios are off even slightly it can do more harm than good. CA can be expensive, so a cost/benefit analysis should be performed. The specific ratios for each type of fruit and vegetable are listed in Section 8: Crop Profiles.

CA is usually created by using an atmosphere generator. Carbon dioxide can be elevated using pressurized gas cylinders. Dry ice can also be used to maintain carbon dioxide levels during modified atmosphere transport.

## Produce Groupings

### Cross Transfer of Odors <sup>12, 13, 14</sup>

A cross-transfer of odors occurs when commodities are stored together, and such a transfer between certain commodities is not desirable. Combinations that should be avoided in storage rooms are:

- Apples or pears with celery, cabbage, carrots, potatoes, or onions (apples and pears acquire an unpleasant, earthy taste and odor when stored with potatoes)
- Apples or leeks with figs
- Odors from apples are readily absorbed by meat, eggs, and dairy products
- Citrus with any strongly scented fruit or vegetable.
- Green peppers and avocados will taint pineapples



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- Ginger with eggplant
- Truffles can significantly affect the odor of other commodities
- It is recommended that onions, nuts, citrus, truffles, and potatoes each be stored separately

## Temperature and Humidity Groupings<sup>15</sup>

- 32-36°F and 90-98% humidity: Waterchestnuts, sprouts, greens and lettuces, turnips, peas, shallots, rhubarb, rutabaga, radishes, parsnips, mushrooms, leeks, jerusalem artichokes, kohlrabi, horseradish, herbs (except for basil), green onions, garlic, fennel, corn, Chinese cabbages, celery, celeriac, cauliflower, carrots, cabbages, Brussels sprouts, broccoli, beets, artichokes, and asparagus.
- 32-36°F and 85-95% humidity: Berries, quince, stone fruits, pomegranates, persimmons, pears (Asian and European), lychee, loquat, longon fruit, kiwifruit, grapes, fig, elderberries, dates, coconuts, cherries, cantaloupe, ripe avocados and apples.
- 45-50°F and 85-95% humidity: Tomatillos, tangerines, summer squash, southern peas, nopalitos, pineapples, peppers, oranges, olives, okra, mandarins, limes, lemons, grapefruit, guava, eggplant, cucumbers, watermelon, potatoes, cranberries, unripe avocados, beans and basil.
- 55-65°F and 85-95% humidity: Tomatoes, sweet potatoes, papayas, mangoes, honeydew melons, jicama, ginger, cherimoya, bananas and atemoya.
- 55-65°F and 65-70% humidity: Onions, pumpkins, and winter squash.

According to organic produce distributor Goodness Greeness, some organic produce needs to be stored at different settings than conventional because they do not use mold or sprout inhibitors. Organic shallots, onions,



dry herbs and cranberries should be stored at 32 to 36°F with low humidity. Organic potatoes should be stored at 34 to 36°F with low humidity.

## Ethylene Groupings<sup>16</sup>

Fruits and vegetables that are sensitive to ethylene should be stored separately from fruits that produce ethylene.

- Ethylene producers: Tomatoes, apples, quince, apricots, cantaloupe, coconuts, figs, longon fruit, loquat, lychees, mushrooms, nectarines, oranges, radishes, peaches, plums, persimmons, pomegranates, and pears (Asian and European).
- Sensitive to ethylene: Watermelon, waterchestnuts, Belgian endive, watercress, broccoli, greens and lettuces, beans, radishes, okra, eggplant, herbs, cucumbers, peas, chard, peppers, pomegranates, mushrooms, kiwifruit, Jerusalem artichokes, cauliflower, squash, carrots, sweet potatoes, cabbage, broccoli, Brussels sprouts and artichokes.

## Storage Structure Design

One of the most important elements of any storage structure is that it provides a cool sheltered area for produce. Ideally the structure should be refrigerated, but at the very least it should be shaded and well ventilated. Ventilation can be improved by having air inlets near the floor and air outlets near the ceiling. An easy and cheap way

to cool storage structures is to open vents at night (provided that the nights are cool) along with running an exhaust fan in the ceiling, and close the vents during the day. This night-cooling method only works for produce that does not need to be cooled to near freezing, as many types do. The storage structure should be well-insulated – at least R20 to R40 on the walls, and possibly more on ceilings.<sup>17</sup> R-values are standard units for insulation levels – the higher the R-value, the greater the level of insulation.

The storage space should be an appropriate size to handle the peak volume of produce, along with space for maneuvering with forklifts and extra setup space. The ideal shape for the storage structure is square, to maximize construction costs and insulation effectiveness. The space should be designed so that produce generally moves in one direction – from entrance to storage to exit. Designing the space so that storage spaces are entered from an interior corridor helps minimize temperature fluxes. Plastic flap doors can also protect against warm air leaking in during loading/unloading.<sup>18</sup>

## Shipping

### Preloading checklist<sup>19</sup>

The following is a suggested preloading checklist:

- Refrigeration unit operating properly?
- Thermostat calibrated?
- Refrigeration air chutes or ducts properly installed and in good repair?
- Door seals in good condition?
- Doors seal tightly when closed?
- Walls free of cracks or holes?
- Front bulkhead installed?
- Floor drains open?

- Inside of the vehicle clean and odor free?
- Floor grooves free of debris?
- Inside length, height, and width adequate for the load?
- Load locks or other devices available to secure load?
- Is the trailer or container pre-cooled or prewarmed?

### Stacking and Loading Patterns

It is important to minimize the amount of contact the produce has with the walls of the truck, as this can result in heat from outdoors being transmitted through the walls and to the produce. Various loading configurations can be used to maximize the cooling during transit.

#### *Loading for top-air delivery*

The crosswise-offset loading pattern (Fig 11-a) can be used for boxed produce; this reduces contact with the walls by 50%. For sacks or bags of produce, the pyramid pattern (Fig 11-b) can be used.

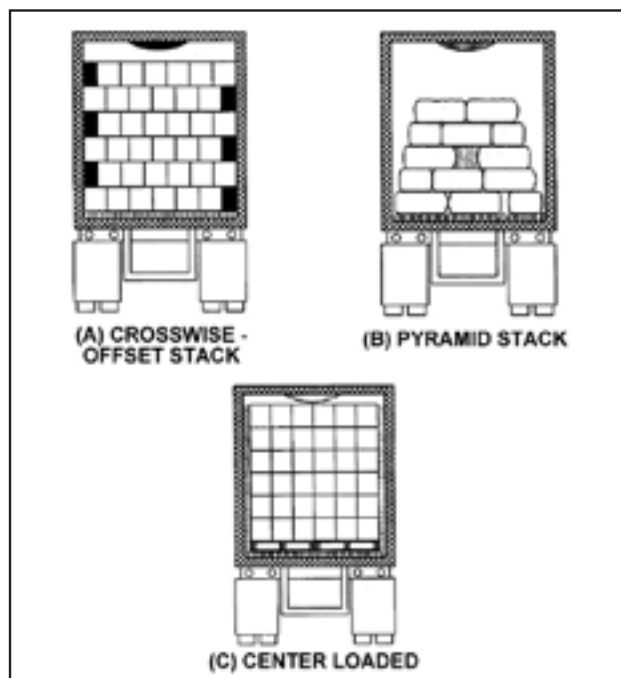


Figure 11: Examples of loading patterns for shipping<sup>20</sup>

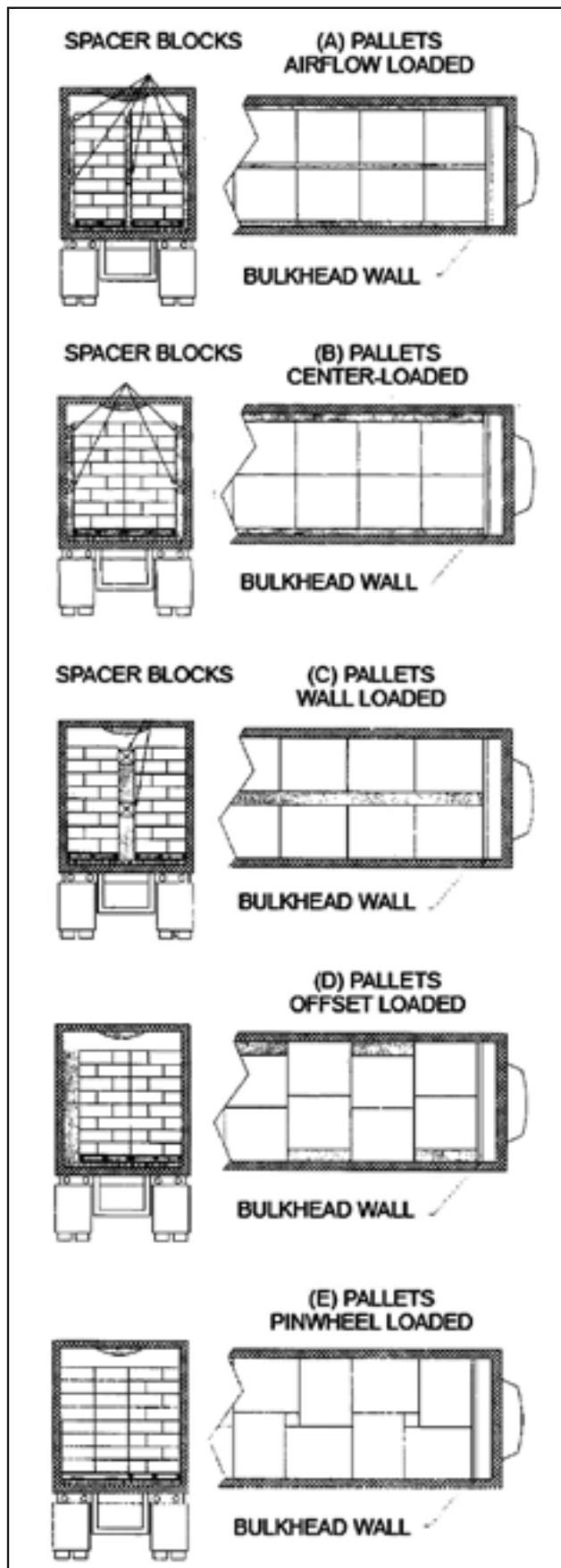


Figure 12: Overhead view of loading patterns<sup>21</sup>

The center-loaded pattern (Fig 11-c) is ideal for palletized stacking. For both unit and palletized loads, there are five additional loading considerations to be considered (Fig 12). Deciding which of these configurations to use depends on how much contact with the walls you want to avoid, and the dimensions of the truck.

Stack boxes so that there are vertical channels in between the boxes for airflow; maintain these channels both horizontally (from the front to the back of the truck) as well as vertically. Load the top layer of boxes in a solid layer. There should be adequate space on top of the boxes, as well as at the rear of the truck, to ensure adequate airflow. There should also be adequate space below the boxes (either through channels on the floor, or pallets). For palletized loads, make sure that the boxes are secured to the pallets, and secure the pallets with spacers and bracing.

### *Loading for bottom-air delivery*

For bottom-air delivery, respiring produce should be packaged in containers with top and bottom vents. Pack the boxes tightly from end to end and side to side. If any space is left at the rear, it should be blocked with T-rails to prevent air from coming around the back instead of going up through the boxes. Make sure that the vents on the tops and bottoms of boxes line up. Also, be sure to leave at least 4 inches of space on top of the stacks of boxes.

### **Loading Checklist<sup>22</sup>**

The following checklist should be used when loading a trailer with top-air delivery:

- Precool vehicle to desired thermostat setting.
- Shut off the refrigeration unit when loading at an open dock.

- Record product temperatures during loading.
- For hand-stacked loads, use an airflow loading pattern with a header stack and lengthwise air channels.
- For both top and bottom air delivery vehicles, avoid loading tight against flat walls; use an offset-by-layers pattern for hand-stacked loads or center-load unit loads.
- Allow at least 4 inches of space between end of load and rear doors for return air.
- Use pallets on floor if floor channels of ducts are less than 2.25 inches deep.
- Secure hand-stacked loads at rear with wood gates, load bars, or other devices.
- Secure unit loads with one or more of the following: air bags, bracing, shrink film or netting, or strapping.

## Ensuring Proper Refrigeration in Transit<sup>23</sup>

Proper refrigeration during transit is essential for most produce. If you do not have access to refrigerated transportation, you should reconsider growing any highly perishable crops.

Although there are many methods of refrigerating produce during transit, by far the most popular method is trailers refrigerated mechanically. Top icing is another method, usually used to complement mechanical refrigeration, that helps ensure proper refrigeration as well as maintain high humidity levels.

As discussed earlier, proper stacking configurations that promote airflow are essential to maintaining refrigeration. It is also important to make sure the refrigeration unit can handle the size of the load you will

be shipping. Produce should be pre-cooled properly; most refrigerated trucks do not have the capacity to cool warm produce, only to maintain the temperature of already cooled produce. Precooling the vehicle can help to ensure adequate refrigeration is maintained. This can be done by shutting the doors to the trailer and running the refrigeration system for up to 2 hours until the temperature has stabilized.

## Determining Proper Temperature for Shipping<sup>24</sup>

The proper temperature for shipping depends on the type of crop being shipped. There are several compatibility groups that require similar temperatures during shipping (note that some items such as tomatoes can fall into several acceptable groups).

- 1. 32-34°F (with 65-75% humidity):** Garlic, onions (dry)
- 2. 32-34°F (with 90-95% humidity):** Apples, apricots, berries, cherries, figs, grapes, peaches, pears, persimmons, plums, pomegranates, quince
- 3. 32-34°F (with 95-100% humidity):** Artichokes, asparagus, beets, carrots, endive and escarole, figs, grapes, greens, *leeks\**, lettuce, mushrooms, parsley, parsnips, peas, rhubarb, spinach, corn, watercress, broccoli, *Brussels sprouts, cabbage, cauliflower, celeriac, horseradish, kohlrabi, onions (green), radishes, rutabagas, turnips*
- 4. 36-41°F:** Cranberries, cantaloupe, lemons, lychees, oranges\*\*, tangerines
- 5. 40-45°F:** Beans, lychees, okra, peppers, summer squash, tomatoes (pink)
- 6. 40-55°F:** Cucumbers, eggplant, ginger, grapefruit (Florida after Jan 1 and Texas), potatoes, pumpkins, watermelon, winter squashes

\* Figs, grapes and mushrooms are not compatible with and should not be shipped with any produce with italicized names

\*\* Shipping temperature depends on source. Florida or Texas grown oranges are shipped at 32-34 F. California or Arizona grown oranges are shipped at 38-48 F.

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7. **55-65°F:** Avocados, bananas, eggplant, grapefruits, guavas, limes, mangoes, honeydew melons, olives (fresh), papayas, pineapples, tomatoes (pink or green), watermelons

### Shipping Routes

Determine where your farm is located in relation to the wholesaler's drop-off routes for produce. Even if you have your own trucks and are able to deliver to wholesale warehouses, taking advantage of trucks in the area that are already making the trip can save you substantial fuel costs and time. Fuel costs can very quickly decrease your profit margins if your drop-off practices are inefficient.

If you are close to trucking routes, you might also be able to grow crops with high respiration levels, shorter shelf life, and potentially higher profit margins because they are so difficult to transport over long

distances. These crops include sweet corn, cantaloupe, figs, peas, and berries.

Truck routes are one of the more important factors in crop selection. If you are comparing wholesale buyers, you may want to factor in truck routes as part of your decision – either existing routes or the possibility of establishing new ones.

Another way of saving time and money is by bringing your produce to a drop-off site – either a walk-in cooler or stationary refrigerated truck.

If you are not located near existing truck routes, you should consider growing crops with lower respiration rates and longer shelf lives, such as hard squash, potatoes, and watermelon. This is a common practice among Amish farmers who do not use refrigeration facilities but readily grow, handle, and ship high volumes of wholesale-quality product.



## Section 6: Postharvest Sanitation

Adequate sanitation and disinfection during postharvest processes is a vital component of a postharvest management plan. As food safety regulations become increasingly important to the sales and marketing of crops, the establishment of proper measures to ensure the elimination of foodborne pathogens is essential. In addition to mitigating potential foodborne illness, proper sanitation during postharvest handling can also minimize the occurrence of postharvest disease and decay. As is the case during the production stage of the crop, all products used during the postharvest period must adhere to NOP regulations (for organic produce only).

### Peroxyacetic acid

Peroxyacetic acid (PAA), in combination with hydrogen peroxide, is a popular alternative to chlorine that is allowed in organic production.<sup>1</sup> Like chlorine, PAA performs well in water dump tanks and water flumes. However, like ozone, the treatments result in safer byproducts than chlorine treatments. The disinfection performance of PAA is comparable to chlorine and ozone. To maximize effectiveness, PAA should be maintained at a level of 80 ppm in the wash water. A post treatment wash with clean water is required after a disinfection treatment with PAA. One popular peroxyacetic acid-based sanitizer is Tsunami ([www.ecolab.com](http://www.ecolab.com)).

### Ozone

Ozone is becoming an increasingly popular alternative to chlorine for water and produce disinfection. Ozone, through its action as an oxidizer, provides comparable disinfection power to chlorine, rapidly attacks bacterial cell walls and thick-walled spores of plant

pathogens. Ozone treatments have the benefit of forming fewer undesirable by-products than chlorine treatments, such as trihalomethane, chloroform, and other dangerous compounds. Ozone is faster acting than chlorine and allows for adequate disinfection with short-term contact to the produce. The use of ozone does require a greater capital investment and ongoing operating costs than the use of chlorine, however. Because of the instability of the compound (20 min in clean water), ozone must be generated on-site, requiring investment in ozone-generating equipment. These generators create ozone through the action of a high-energy source (UV light or corona discharge), splitting oxygen molecules that then recombine to form ozone. Small-scale ozone generating units are available for a few thousand dollars.

### Chlorine

Chlorine is a very common disinfectant that can be added to produce cooling or wash water, however growers are increasingly choosing to use methods without the toxic fumes. Liquid sodium hypochlorite (bleach) is typically used, with the pH of the water maintained between 6.5 and 7.5 to optimize effectiveness.<sup>2</sup> The NOP approves chlorine's use in postharvest management as an algicide, disinfectant, and sanitizer. These regulations do restrict residual chlorine levels in water at the discharge or effluent point to the maximum residual disinfectant limit under the Safe Drinking Water Act, currently established at 4 mg/L for chlorine by the Environmental Protection Agency (EPA). However, the levels of chlorine used to prepare water for sanitation of tools, equipment, product, or food contact surfaces may be higher than 4 mg/L and should be in high

enough concentrations to control microbial contaminants. Thus, the concentration of chlorine at the beginning of a disinfection treatment is generally greater than 4 mg/L. However, care must be taken to ensure that the effluent water does not exceed this limit.

Chlorine can exist in water in various forms. Free chlorine may be found as hypochlorous acid and hypochlorite ion, with the hypochlorous acid form providing the strongest antimicrobial properties. At a pH of 6.5, 95% of the chlorine is in the hypochlorous form; maintaining the water pH at this range provides the greatest disinfecting power. Chlorine may become bound to dirt, debris, and other organic matter in the water; once chlorine becomes combined with these materials, it is no longer available for disinfection. In order to maximize the effectiveness of any chlorine treatment, it is beneficial to perform additional cleaning steps to produce arriving from the field. This may include a vigorous prewash with brushes or sponges to remove excess debris from the produce. Also, cleaning out dump tanks and residue screens will help minimize the presence of dirt and debris and maximize chlorine's effectiveness.

### Other Cleaners and Sanitizers Allowed for Organic<sup>3</sup>

- **Acetic acid.** Allowed as a cleanser or sanitizer. Vinegar used as an ingredient must be from an organic source.
- **Alcohol, Ethyl.** Allowed as a disinfectant. Alcohol must be from an organic source.
- **Alcohol, Isopropyl.** May be used as a disinfectant under restricted conditions.
- **Ammonium sanitizers - Quaternary ammonium** salts are a general example in this category. Quaternary ammonium may be used on non-food contact surfaces. Its use is prohibited on food contact surfaces, except for specific equipment where alternative sanitizers significantly increase equipment corrosion. Detergent cleaning and rinsing procedures must follow quaternary ammonium application. Monitoring must show no detectable residue prior to the start of organic packaging (ex. fresh-cut salads).
- **Bleach.** Calcium hypochlorite, sodium hypochlorite and chlorine dioxide are allowed as a sanitizer for water and food contact surfaces. Product (fresh produce) wash water treated with chlorine compounds as a disinfectant cannot exceed 4ppm residual chlorine measured downstream of product contact.
- **Detergents.** Allowed as equipment cleaners. Also includes surfactants and wetting agents. All products must be evaluated on a case-by-case basis.
- **Hydrogen peroxide:** Allowed as a water and surface disinfectant.
- **Ozone.** Considered GRAS (Generally Regarded As Safe) for produce and equipment disinfection. Exposure limits for worker safety apply.
- **Carbon dioxide.** Permitted for postharvest use in modified and controlled atmosphere storage and packaging. For crops that tolerate treatment with elevated CO<sub>2</sub> (>15%), suppression of decay and control of insect pests can be achieved.
- **Fumigants.** Naturally occurring forms are allowed (ex. heat vaporized acetic acid). Must be from a natural source.
- **Wax.** Must not contain any prohibited synthetic substances. Acceptable sources include caruba or wood-encrusted wax.

## Section 7: Food Safety

Food safety has become extremely important in agriculture and is key for farms of all sizes. Foodborne illnesses can cause serious health issues, some even fatal, and an outbreak linked to your farm will also seriously affect your reputation. It is always advisable, both from a practical and financial perspective, to minimize the risk of contamination rather than wait for corrective action after an outbreak. Having a food safety plan with proper documentation is recognized as a wise business practice.

The risk of microbial contamination of fresh produce and other agricultural products exists regardless of the methods of land management and cultivation practices used by the grower. While fresh fruit and vegetable consumption has increased significantly over the past thirty years, foodborne illnesses associated with fresh produce have increased at a greater rate. Continued consumer consumption of the fresh fruits and vegetables that are so important to a balanced diet will depend on each grower's efforts to assure the safety of their produce.

Despite growing concern about the quality of imported food, a large portion of food contamination (greater than 75% of outbreaks) occurs in domestic production, often due to a lack of oversight and clear sanitation practices. In 1998, The Food and Drug Administration (FDA) published a series of guidelines for reducing the risk of microbial contamination in fresh fruits and vegetables titled "Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables," predominantly aimed at minimizing the risk of foodborne illness. The guide is available online, along with a recent publication specifically related to fresh cut produce, in the "Produce and



Photo: Betsy Blinn

### Why Care About Foodborne Illness?

The Center for Disease Control and Prevention (CDC) estimates that each year foodborne illnesses result in an estimated: <sup>1</sup>

- 76 million cases of food poisoning;
- 325,000 hospitalizations;
- 5,200 deaths; and
- \$10 to \$83 billion in economic losses.
- Approximately 12% of these illnesses are traced back to fresh produce.

An outbreak of E. coli 0157:H7 contamination in 2006 sickened 199 people including 3 who died. Spinach sales plummeted as a result and are still significantly lower than before the incident. Growers, distributors, retailers, and other stakeholders have suffered hundreds of millions of dollars of losses as a result.

**Based on the increase in foodborne outbreaks associated with fresh fruits and vegetables, a growing number of wholesale buyers require their suppliers to obtain Good Agricultural Practices (GAP), Good Handling Practices (GHP), or Hazard Analysis and Critical Control Point (HACCP) certification. Growers are having to absorb the costs of these inspections.**



Plant Products” section at <http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/default.htm>

For the purposes of this publication GAP (Good Agricultural Practices) recommendations from the FDA and AFDO (Association of Food and Drug Officials) have been predominantly used. GAP information has either been reproduced directly or written to reflect the sentiment of the recommendations and, unless otherwise specified, has been used interchangeably whenever the term “GAPS” is referenced in this document.

## Good Agricultural Practices/ Good Handling Practices Overview

Good Agricultural Practices/Good Handling Practices GAP/GHP are a series of on-farm practices designed to minimize the risk of food contamination, maintain a clear record of how food was handled and stored, and assure the people buying your produce that it is coming from a clean, well-managed environment.

While contamination can occur at any stage between the farm and the dinner table, it is the farmer’s responsibility to take care of the first, and most important stages. The risk of contamination can be reduced by meeting the generally accepted food safety standards represented by the GAP/GHP guidelines. According to FDA guidelines, there are eight general aspects of your farm operation that will need to be considered<sup>2</sup>. They include the following principles:

**Principle 1:** Prevention of microbial contamination of fresh produce is favored over reliance on corrective actions once contamination has occurred. It is always advisable, both from a practical and financial perspective, to minimize the risk of



Photo: Harmony Valley Farm

## Develop an On-Farm Food Safety Plan<sup>3,4</sup>

The following topics should be covered in your food safety plan for each stage of your operation; from deciding on the where to plant your crops, to harvesting, to processing and dispatching them to your applicable markets.

- Soil and land use history
- Water quality, monitoring and use considerations
- Soil amendments – use and storage
- Animals
- Worker health and hygiene
- Toilet and handwashing facilities
- Sewage disposal
- Employee training
- Equipment sanitation
- Harvest and post harvest handling
- Transport vehicles
- Product tracing system
- Crisis management strategy

## WHOLESALE SUCCESS Section 7: Food Safety

contamination rather than wait for corrective action. The cost of cleanup following contamination will almost invariably exceed any perceived savings from only dealing with contamination after the fact.

**Principle 2:** To minimize microbial food safety hazards in fresh produce, growers, packers, or shippers should use good agricultural, handling and management practices in those areas over which they have control.

**Principle 3:** Fresh produce can become microbiologically contaminated at any point along the farm-to-table food chain. The major source of microbial contamination with fresh produce is associated with human or animal feces.

**Principle 4:** Whenever water comes in contact with produce, its source and quality dictates the potential for contamination. Minimize the potential of microbial contamination from water used with fresh fruits and vegetables.

**Principle 5:** Practices using animal manure or municipal biosolid wastes should be managed closely to minimize the potential for microbial contamination of fresh produce.

**Principle 6:** Worker hygiene and sanitation practices during production, harvesting, sorting, packing, and transport play a critical role in minimizing the potential for microbial contamination of fresh produce.

**Principle 7:** Follow all applicable local, state, and Federal laws and regulations, or corresponding or similar laws, regulations, or standards for operators outside the US, for agricultural practices.

**Principle 8:** Accountability at all levels of the agricultural environment (farm, packing

facility, distribution center, and transport operation) is important to a successful food safety program. There must be qualified personnel and effective monitoring to ensure that all elements of the program function correctly and to help track produce back through the distribution channels to the producer.



Photo: Eric Erbe

### Manure is a Source of E-Coli Contamination

If a head of lettuce has 1 bacterium on it and it is in the right environment in 140 minutes, it could multiply to over 100 organisms. According to the Foodborne Pathogenic Microorganisms and Natural Toxins Handbook produced by the FDA, the infective dose (amount resulting in illness) of E.coli O157:H7 could be as few as 10 organisms.<sup>5</sup>

Food safety experts are increasingly recommending that **only properly composted manure** is used on fields growing fresh fruits and vegetables (see page 70 for more details on composting manure).

Source: Cornell University Good Agricultural Practices Project [www.gaps.cornell.edu](http://www.gaps.cornell.edu)

### Hazard Analysis and Critical Control Points (HACCP)

HACCP is designed for use in many segments of the food industry including processing, manufacturing, distributing, merchandising and preparing food for consumption. It is not frequently used on produce farms, unless they also do on-farm processing. Nonetheless, HACCP discusses a number of good practices for identifying potential sources of contamination or problems with a farm's system for handling produce, particularly when animals are present on the farm. It is a management system in which food safety is addressed through the analysis and control of biological, chemical, and physical hazards from raw material production, procurement and handling, to manufacturing, distribution and consumption of the finished product.

Often a wholesale buyer will ask for a HACCP program for a packinghouse. The intent here is to identify all of the hazards within the packinghouse (just as one would work to identify all of the risks posed in the field and during harvest for a GAP/GHP program), document them, establish procedures to measure them and to take corrective action to prevent those hazards from contaminating the finished produce. Much of the structure of the GAPs/GHPs program is borrowed from the principles of HACCP.

The FDA's HACCP manual is available online at:  
[www.cfsan.fda.gov/~dms/hret2toc.html](http://www.cfsan.fda.gov/~dms/hret2toc.html)

### On-Farm Food Safety Plans

Developing and following a food safety plan is a key step toward minimizing the risk of contamination on your farm. A food

safety plan is a written plan, based on GAP/GHP guidelines, that is unique to your operation. To develop your plan, you will perform a comprehensive assessment of specific risks for food contamination within your operation. Possible sources of contamination include:

- Soil
- Irrigation and spray water
- Animal manure
- Wild animals and birds
- Pets
- Field workers
- Harvesting equipment
- Soak/pack equipment
- Ice
- Cooling units
- Transport vehicles
- Improperly stored produce
- Wash and rinse water

The most significant sources of contamination are water and fecal matter. Water is especially good at transporting pathogens over long distances and contaminating produce during postharvest washing and rinsing. Some common pathogens which travel well in water include: *Escherichia coli*, *Salmonella spp.*, *Vibrio cholerae*, *Shigella spp.*, *Cryptosporidium parvum*, *Giardia lamblia*, *Cyclospora cayetanensis*, and *Toxoplasma gondii*. Humans are another good source for these pathogens as well as viruses (such as Norovirus and Hepatitis viruses).

For the purpose of clarification we will discuss areas in which possible contamination can arise and ways to reduce the risk. These areas should be covered in

your food safety plan for each stage of your operation; from deciding where to plant your crops, to harvesting, processing, and dispatching them to your markets.

## Soil and Land Use History <sup>6,7</sup>

While many farms have been in the family for decades, others are newly purchased. In either case, the land may have been used in previous years for purposes other than growing fruits and vegetables and this can have an impact on food safety.

- Be aware of the current and historical use of land.
- Be aware of neighboring land use and practices such as spraying that may effect your adjacent crops.
- Consider the slope and porosity of your soil. Ensure that fields are upstream and upwind from animal contaminants.
- Ensure that contaminated water or livestock waste cannot enter a field via runoff or drift.

Potential previous industrial use, chemical spill contamination and trash dumpsites are to be avoided.

Your neighbors' practices may also affect your crops' safety, particularly if they are running any kind of animal husbandry operation or spraying adjacent land. Be aware of those risks and work with your neighbors to minimize them. Also, be aware of flooding patterns when you select fields for growing fresh fruits and vegetables. Have a plan for isolating crops that have been contaminated by flood waters and prepare to destroy them so they can't be accidentally sold.



Photo: Trevor Suslow

## Wash Water Quality

- Use potable water for all produce washing, cooling, dipping, icing and processing.
- Use an appropriate sanitizer in water for these purposes.



Photo: Trevor Suslow

## Stemscar Vulnerable to Wash Water Contamination <sup>8</sup>

Bacteria can enter the stem scar with improper handling or wash water management. Proper culling is important to both food safety and quality.

Source: Cornell University Good Agricultural Practices Project  
[www.gaps.cornell.edu](http://www.gaps.cornell.edu)

## Agricultural Irrigation Water <sup>9,10</sup>

**Wherever water comes into contact with fresh produce, its quality dictates the potential for pathogen contamination.**

Water used for irrigation and sprays may become a source of microbial contamination. As mentioned above, water is an excellent transport system for microorganisms that come from fecal contamination and other sources. The following points will help you reduce your risk for microbial contamination:

- Identify source and distribution of water used. Document using maps, photographs, hand drawings or other means to show water source location, flow and permanent fixtures.
- Review existing practices and conditions to identify potential sources of contamination. For example open water sources are subject to potential contamination from animals and birds. Consider practices that will protect water quality.
- Water quality should meet all applicable federal and state laws and regulations.
- Ensure water systems used to transport untreated human or animal waste are separated from those used to deliver agricultural water.
- If you are not using municipal water, test your water for fecal coliforms and E. coli. Action is considered necessary if the fecal coliforms are greater than 1000 in 100 mls of water<sup>11</sup>. Test open water sources at least four times a season in warm climates such as California, Florida, Texas and other southern states. Test three times during the growing season in northern climates such as New York, Pennsylvania, and Michigan. Test enclosed well water biannually and treat if fecal coliforms are present<sup>12</sup>.

- Maintain wells in good working condition. Inspect them monthly for leaks and cracks that could allow contamination.
- Consider practices to minimize contact of the edible portion of fresh produce with contaminated irrigation water (i.e. drip irrigation) Where water quality is good, risk is low regardless of irrigation method.

Join your local watershed group to participate in decisions and increase your awareness of water use in your area.

## Manure and Soil Amendments <sup>13, 14</sup>

**Properly treated manure can be an effective and safe fertilizer.**

- If manure is used as a fertilizer, it should be managed to minimize microbial hazards.
- Federal regulations address the requirements for use of biosolids (sewage sludge) in the U.S. The use of sludge is forbidden in organic production.
- Use treatments to reduce pathogens in manure and other organic materials. Treatments may be active (e.g., composting) or passive (e.g., aging).
- Manure treatment and storage sites close to fresh produce fields increase the risk of contamination. Make sure they are not adjacent to each other and that traffic patterns do not permit cross contamination.
- Consider factors such as slope and rainfall and the likelihood of runoff into fresh produce production areas.
- Use barriers or physical containment to secure storage and treatment sites.
- When purchasing treated manure, get information about the composition and



## Keys to Safe Composting of Manure

The National Organic Program has a very strict guideline for composting manure. “Compost must be produced through a process that combines plant and animal materials with an initial Carbon:Nitrogen ratio of between 25:1 and 40:1. Producers using an in-vessel or static aerated pile system must maintain the composting materials at a temperature between 131°F and 170°F for 3 days. Producers using a windrow system must maintain the composting materials at a temperature between 131°F and 170°F for 15 days, during which time, the materials must be turned a minimum of five times.” Compost piles must be managed to ensure high temperatures, good moisture, proper aeration, and mixing. Regular temperature testing is key to composting manure safely! Animals should be excluded from compost area to prevent recontamination.<sup>15</sup>

method of treatment. Also document time and method of application.

- Maximize the time between application of compost to production areas and harvest.
- Use of raw manure on crop production areas is not recommended. Avoid top or side dressing with manure.

- When using a product containing any combination of raw and treated manure, it needs to meet the same requirements as a product containing raw or incompletely treated manure.
- Make sure that equipment that comes into contact with raw or incompletely treated manure does not become a potential source of contamination.

## Animals<sup>16,17</sup>

**While not possible or desirable to exclude all animal life from fresh produce production areas, many field programs include elements to protect crops from animal damage. A balance must be sought between protecting crops from pathogenic contamination and fostering natural processes that support pollination, pest control, connectivity, and clean water.**

- Assess the risk of contamination from domestic and wild animals for your operations. Areas to consider include crop characteristics (hand versus machine-harvested crops), type and number of animals (large numbers of any animals, wild or domestic, increase risk), pathogens of concern (especially E. coli 0157: H7 and Salmonella), nearness to the growing field (high risk animals or polluted areas animals have walked through), and proximity to harvest.
- Based on your assessment, put into place measures to exclude or minimize domestic and wild animals from growing fields as applicable. Possibly consider practices to deter or redirect wildlife to areas where crops are not destined for fresh produce markets.
- When domestic animals are used in farming operations minimize the potential for contamination from animal urine and feces.



Photo: Paul Natkin

## All Manure Can Carry Pathogens and Must Be Controlled<sup>18</sup>

- Livestock including cattle, swine, poultry, horse, sheep, and goats.
- Dogs, cats, birds, rodents, deer, wild pigs, flies and other insects, humans.

### Proper Control Includes:

- Keeping large amounts of wildlife out of production areas as much as possible.
- Managing rodents, pets, insects, and birds in packing house and storage areas.
- No weeder geese in fields prior to harvest.

Source: Cornell University Good Agricultural Practices Project [www.gaps.cornell.edu](http://www.gaps.cornell.edu)

- Ensure animal waste from adjacent fields, pastures, or waste storage facilities does not contaminate fresh produce production areas. Where necessary, consider physical barriers such as ditches, mounds, grass/sod waterways, diversion berms, hedgerows, and vegetative buffer areas .
- Make sure fields, as well as the structures and equipment within or adjacent to them, are managed to minimize harborage of pests and wildlife.

## Chemical Usage

- Any applications of pesticides (e.g. insecticides, rodenticides) must be performed in compliance with local, state, and federal pesticide regulations.
- If herbicides are used, they should be used in accordance with label instructions and in compliance with federal, state and local regulations.
- Care must be taken to ensure usage and disposal of such chemicals do not jeopardize food safety or result in contamination of land or water resources.
- Any chemical leakages or spills need to be managed and disposed of based on applicable laws and regulations, and in a manner that prevents or minimizes contamination of produce and growing fields.

## Worker Health and Hygiene<sup>19,20</sup>

### Infected employees who work with fresh produce increase the risk of transmitting foodborne illness.

- Train all employees to follow good hygienic practices especially handwashing. Proper handwashing means: using clean (preferably warm) water and soap for 20 seconds, rinsing with clean water, and wiping dry with single-use paper towels. Employees should wash their hands before starting work, after using the toilet, after each break, and whenever their hands may have become a source of contamination. Hand sanitizers should not be used as a substitute for hand washing.
- Establish a training program directed toward health and hygiene – including basics such as proper handwashing techniques and the importance of using toilet facilities. The program should also

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cover any specific job responsibilities that may impact food safety.

- Become familiar with typical signs and symptoms of infectious diseases. Anyone showing signs of illness (e.g. vomiting, jaundice, diarrhea) should be restricted from direct contact with produce or food-contact surfaces.
- Offer protection to workers with cuts or lesions on parts of the body that may make contact with fresh produce. If the lesion can not be effectively covered then the worker will need to be restricted from direct contact with produce or food-contact surfaces.
- Employees and visitors should be made aware of the need to seek prompt treatment for cuts, abrasions, and other injuries and should be told that any signs of illness must be reported to a supervisor before starting work.
- Eating, drinking, spitting, chewing gum and using tobacco should be restricted to designated areas away from production fields or packing areas.
- If employees wear gloves, be sure the gloves are used properly and do not become a vehicle for spreading pathogens. Hands should be washed before gloves are put on and between changing gloves. Ensure that employees are aware that glove use does not lessen the need for proper hygiene practices.
- Establish a written policy on your requirements regarding the use of hair coverings (e.g., hair nets, beard nets, caps), and the wearing of artificial fingernails and jewelry. The policy should cover your requirements for field and packinghouse areas.
- Customer-pick and roadside produce operations should promote good hygienic practices with customers – encourage handwashing, provide toilets that are

well-equipped, clean and sanitary, and encourage washing fresh produce before consumption.

- Consider designating a person to be responsible for ensuring all employees and visitors understand health and hygiene requirements for your operation.
- Any training performed should be documented as part of your food safety plan. It is also good practice to undertake periodic refresher or follow-up training as appropriate.



Photo: Betsy Blinn

Field toilets should include hand-washing stations

### Sanitary Facilities<sup>21,22</sup>

**Poor management of human and other waste in the field or packing facility increases the risk of contaminating fresh produce.**

- Be familiar with laws and regulations that apply to field and facility sanitation practices.
- Toilet facilities and hand-washing stations should be accessible to workers, properly located (away from produce handling areas), kept clean and well supplied with toilet paper, water, soap and single use paper towels.



- Water used for hand-washing should be potable and meet the standards for drinking water.
- Keep toilets, hand-washing stations, and water containers clean and sanitary. Service and clean on a regular schedule to ensure they are suitable for use.
- Use caution when servicing portable toilets to prevent leakage. Locate them so as to minimize contamination risk to produce fields and the packing facility. They should also be directly accessible for servicing.
- Maintain sewage and septic systems to prevent contamination of produce in the field and packinghouse.
- Have a plan for containment in the event of waste spillage. Leakages or spills need to be managed and disposed of based on applicable laws and regulations, and in a manner that prevents or minimizes contamination of produce and growing fields.

## Field Sanitation<sup>23,24</sup>

**Fresh produce may become contaminated during pre-harvest and harvest activities from contact with soil, fertilizers, water, workers, and harvesting equipment.**

- Any storage sheds, buildings or other structures, equipment, and containers in the field used to contain produce should be clean and sanitized when appropriate.
- Clean harvest storage facilities and containers or bins prior to use.
- Use harvesting and packing equipment, pallets, machinery and utensils appropriately and keep as clean as practicable.
- It is recommended that any field-based washing, grading, sorting, and packing lines be cleaned and sanitized, at least daily when in use.
- Inspect field-based cooling equipment at an appropriate frequency. Equipment should be cleaned and sanitized as necessary with all debris removed.
- Harvesting and packing equipment that is no longer cleanable should not be used for harvest. It can be used for other nonfood uses if clearly marked or labeled.
- Make sure harvest totes, bins, and other equipment are not used for other purposes.
- Store harvesting containers and equipment so as to minimize potential contamination.
- Assign responsibility for equipment to a designated person.
- Take care not to contaminate fresh produce that is washed, cooled, or packaged.
- Remove as much dirt and mud from produce as possible in the field.
- If appropriate for the product being harvested, minimize temperature increases and the time between harvest and destination.
- Do not harvest dropped, bruised or damaged fruits or vegetables. Also avoid fruit or vegetables with signs of animal droppings on them, These may be a source of microbial contamination.

## Processing Water<sup>25,26</sup>

Water Used in Harvest, In-field and Packinghouse Operations

**Washing Produce Does Not Eliminate Pathogens. The goal of washing is to reduce the risk of multiplying the presence of microorganisms.**

- In a similar fashion to water used for irrigation, the water system used for harvest, in-field and packinghouse activities should also be documented. Maps, photographs, hand drawings, or other means can be used to show water source locations, flow, and permanent fixtures.
- Review existing practices and conditions to identify potential sources of contamination. Consider practices that will protect water quality.
- Water that directly contacts the harvested crop or food contact surfaces needs to meet drinking water standards. There may be special considerations for some crops such as cranberries and watercress, where fields are deliberately flooded.
- Make sure your water delivery system is sufficient in size and design for your operations and installed and maintained so it doesn't become a source of contamination. There should be no back-flow from, or cross-connection between piping systems that discharge wastewater or sewage.
- Periodically assess your water use and water system including water source and quality, delivery systems, and equipment. Document your assessment.
- Routinely inspect and maintain any equipment used for maintaining water quality, such as chlorine injectors, filtration systems, and backflow devices.



Photo: Vick Ball, Flickr/160633434

## Know Water Source Quality<sup>27</sup>

- Municipal Drinking Water is lowest risk.
- Ground water is less likely to have microbial contaminants than surface water.
- Keep livestock away from active well recharge areas.
- Surface water quality and pathogen levels are affected by watershed activities and season.

Source: Cornell University Good Agricultural Practices Project  
[www.gaps.cornell.edu](http://www.gaps.cornell.edu)

- For postharvest washing, rinsing, and precooling processes involving water, the water quality should be regularly monitored and recorded. Reusing wash or hydrocooling water is standard practice and recommended, but increases the possibility of microbial contamination.
- Sanitation of food contact surfaces and water quality monitoring for equipment such as dump tanks, flumes, wash tanks, and hydrocoolers should be performed at an appropriate frequency to maintain sanitary conditions. All debris should be removed and surfaces cleaned and sanitized as necessary.

- Water change frequency should be considered as part of your food safety plan for all post-harvest uses of water (in-field processing and packinghouse operations).
- Antimicrobial chemicals may help minimize the potential for microbial contamination to be spread by processing water; levels of antimicrobial chemicals should be routinely monitored and recorded to ensure they are maintained at appropriate levels. Chemicals should be used in accordance with federal and local regulations and label instructions for concentration and contact time or other requirements (e.g., pH).
- As organic material and microbial load increase, the effectiveness of many antimicrobial chemicals will decrease. Filtering recirculating water or scooping organic material from tanks may help reduce the build-up of organic materials, but does not eliminate pathogens. Monitor at appropriate intervals to maintain efficacy.
- Where necessary for food safety, monitor temperature of post harvest water used in field or packinghouse equipment (such as dump tanks and flumes) to ensure it remains appropriate for the product.
- Wash water temperature should be monitored to prevent internalization of microorganisms from the water into the produce, where applicable.

For some types of produce (apples, celery, tomatoes for example) the temperature of wash water should be greater than that of the produce or a pressure differential results that can cause water to be pulled into the plant material. If there are pathogens present on the produce surface or in the water they can become internalized. Subsequent washing will not reduce

pathogen levels once they are internalized. For further information and examples of this phenomenon please refer to FDA websites <http://www.fda.gov/Food/FoodSafety/HazardAnalysisCriticalControlPointsHACCP/JuiceHACCP/ucm082063.htm> and <http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/ProduceandPlanProducts/ucm064574.htm>.

### Cooling Operations<sup>28,29</sup>

**Temperature Control is an Important Step in Reducing Microbial Growth. Care must be taken that cooling and chilling equipment does not become a source of microbial contamination.**

- Maintain temperatures that promote optimum produce quality and minimize pathogen growth. The crop profiles given in Section 8 provide recommendations on cooling methods and storage temperatures for various crops.
- Inspect cooling equipment at an appropriate frequency. Clean and sanitize as necessary and remove all debris when in use.
- Clean and sanitize interiors of hydrocoolers and other cooling equipment as frequently as needed for your operation.
- Air cooling equipment and cooling areas should be clean and sanitary and inspected on a periodic basis. Make sure air intakes are not be located near potential sources of contamination.
- Keep water and ice clean and sanitary. Freezing does not inactivate all microorganisms. Some, such as *Listeria*, actually can grow under refrigerated conditions.

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- If you use ice in your operations, it needs to be made from potable water that meets standards for drinking water. Manufacture, transport, and store ice under sanitary conditions.
- Ensure containers holding finished produce during chilling operations are clean and sanitary.

## Packing Facility<sup>30,31</sup>

**Maintain packing facilities in good condition to reduce the potential for microbial contamination.**

- Remove as much dirt as is practical from produce outside of packing facility.
- Make sure that lines used for washing, grading, sorting, or packing are cleaned and sanitized before use. Maintain them when in use so they don't become a source of contamination.
- Containers, bins, and other packing containers should be clean and sanitary before use. When in use, maintain them in a condition that minimizes the potential for contamination.
- Keep packing equipment and machinery, packing areas, and storage areas clean. Develop a sanitation schedule to ensure clean food contact surfaces.
- Ensure the types and construction of packing containers and equipment are appropriate for the produce being packed.
- Food-contact totes, bins, and other packing containers and equipment that can no longer be adequately cleaned should not be used for packing. They can be used for other nonfood uses if clearly marked or labeled.
- Ensure totes, bins, and other harvest containers and equipment designated for packing are not used for other purposes.
- Pallets should be kept clean and in good condition as appropriate for their intended use.
- Store empty containers and equipment in a way that protects them from contamination.
- Consider designating a person to be responsible for inspecting food-contact totes, bins, and other packing containers and equipment prior to packing and as needed.
- Inspect hoses, walls, ceilings, and floors for potential cracks and openings that could harbor microorganisms or allow for pest intrusion.
- Avoid standing water in and around the packinghouse.



Photo: L. Halley

Harmony Valley Farm packing house

## Pest Control<sup>32, 33</sup>

**Rodents and other pests can carry microorganisms that cause foodborne illness. Keep them from the packing shed as much as possible.**

Eliminating pests from your packing shed requires some changes in your usual practices that will be well worth the effort. Using screens and poly curtains to reduce

the opportunity for pests (rodents, birds, and insects) to get into your facility is the first step in reducing your risk. Rodent traps that do not use poison (poison may become a source of contamination in a packing shed) are another important tool. Documenting your efforts and keeping a log of your inspections are a critical part of a food safety program.

- Establish and maintain a pest control program that includes regular and frequent monitoring to assess the program's effectiveness.
- Develop a policy restricting domestic animals from the packing facility and maintain the premises so harborage of pests and wildlife is minimized.
- Minimize the availability of food and water to animals and pests.
- Inspect for signs of pests in the packinghouse and take steps to eliminate them when they are found. Particularly watch for signs of nesting and bird droppings.
- Maintain a pest control log that includes dates of inspection, inspection reports, and steps taken to eliminate any problems.

### Transportation and Loading Vehicles<sup>34,35</sup>

**Whether it be from the field to the packinghouse or from your farm to customers, proper transport of fresh produce will help reduce the potential for microbial contamination.**

- Good hygienic and sanitation practices should be used when loading, unloading, and inspecting fresh produce.
- Train personnel in the food safety requirements for proper handling and transport of produce.

- Inspect transportation vehicles for cleanliness, odors, obvious dirt and debris (i.e., meat debris) before loading.
- Clean cargo and container areas if they are found to be unsanitary. If they have been used to transport trash, animals, raw animal products, or other items, the area must be cleaned and sanitized by a procedure sufficient to ensure that contamination of produce does not occur.
- If refrigeration is required for product safety, the cargo area should be pre-cooled to a temperature appropriate to the type of produce, or by agreement between the shipper and carrier if applicable.
- Load produce to minimize physical damage.
- The temperature should be maintained during transport and controlled by a thermostatic device as necessary. Be certain the container has reached temperature before and after loading.
- Print temperature requirements on the bill of lading.

### Traceback<sup>36,37</sup>

**The ability to identify the source of a product can serve as an important complement to good agricultural and management practices and is increasingly being required by many wholesale purchasers and certification agencies.**

- Develop procedures to track produce containers from the farm, to the packer, distributor, and retailer as applicable. Records need to identify the immediate past source of the produce and immediate subsequent recipient of the produce. A simple code system can be used. The key is that you understand your code.

- Documentation should indicate the source of the product and other information, such as date of harvest, farm identification, product identification, lot identification, quantity, date shipped or received, immediate subsequent recipient of the produce, and who handled the produce.
- For every batch shipped, your records should be readily available, legible, and contain all the information to enable effective tracing to the source of all produce.
- Labels and/or labeling needs to be accurate and contain sufficient information to assure product tracing.
- If there is commingling or repacking of produce, maintain records for the raw product that enable tracing of all incoming products to outgoing products in which they are components.
- Growers, packers, and shippers might consider partnering with transporters, distributors and retailers to develop technologies to facilitate the traceback process.

## Crisis Management Plan

In the event of a crisis, such as a product contamination incident or the death of an employee/owner, ensure that there is an individual or team with designated responsibility to ensure effective management of the situation. Consider possible crisis scenarios for your operation and develop a plan of action.

## Record Keeping<sup>38,39</sup>

Proper record keeping is an essential part of any food safety plan and has a number of benefits. First, it is often required for any wholesale contract and for third-party audit certification. Secondly, in the case of a

foodborne outbreak, it helps quickly identify any issues and enables prompt response to inquiries in the event of an outbreak. Farmers with proper food safety practices (maintaining the cold chain, sanitation facilities, policies and training for worker health, and working with produce, etc.) can demonstrate that contamination most likely did not occur on the farm and protect themselves from liability claims. If a grower's practices are not documented there is no way to prove that they were followed.

Record keeping to document your good agricultural practices does not need to be complicated. There just needs to be a written record (hand written or otherwise) of these activities that is legible, up to date, and readily available.

Some of the records that should be part of your food safety plan documentation include:

- Create a map of the farm operations.
- The map can be hand-drawn or a Google™ map, for example, and should indicate north and show buildings, fields, roads, major land marks such as nearby towns, water features, etc. Approximate distance to nearest towns and major roads should also be included.
- Draw a floor plan of the packinghouse indicating flow of product, storage areas, cull areas, break rooms, restrooms and offices.
- Attach any information associated with soil and land use history.
- Describe (with maps, photographs, hand drawings, etc.) the water source location and distribution for irrigation and harvest/packinghouse process water.
- Attach records of any water testing (irrigation or harvest/packinghouse) or well inspection records, if applicable.

- Include information about the composition and method of treatment for purchased treated manure and the time and method of application in your fields.
- Show training records on good hygiene practices for all employees.
- Include illness/injury report forms.
- Include the cleaning and service records for sanitation facilities.
- Show sanitation records for field and packinghouse equipment, storage areas, and transport vehicles as applicable.
- Attach any risk assessments or routine equipment inspections performed.
- Include monitoring records for antimicrobial chemical levels.
- Keep cooling equipment temperature records (including transportation vehicle, if applicable).
- If ice is used, attach records indicating that is made from potable water and manufactured, stored, and transported under sanitary conditions.
- Keep a pest control log and any animal monitoring activities such as fence and field inspections.
- Attach records to ensure traceability of product, planting records, harvest records, etc.

Once good agricultural and management practices are in place, ensure that the process is working correctly. Someone needs to be designated to implement and oversee your food safety plan. This can be one person or a number of individuals with designated responsibilities. Without accountability, even the best efforts to minimize microbial contamination are subject to failure.

### Tools to Help You Develop an On-farm Food Safety Plan

Many training materials exist to help assist you in developing a food safety plan, training employees on the importance of food safety, and how to minimize contamination of food products. The Food Safety Begins on the Farm program from Cornell University, has helped many growers across the country improve their practices and reduce their risks for foodborne illness. Educational materials from the program include brochures in English and Spanish, a booklet, A Grower Self Assessment Guide, bilingual worker training tapes, training posters and many other useful tools. The materials for Food Safety Begins on the Farm are available at [www.gaps.cornell.edu](http://www.gaps.cornell.edu). GAP/GHP training for you or one of your supervisors can also be accomplished by attending Fresh Produce Food Safety seminars offered at various grower meetings or by purchasing the GAP/GHP booklets and self assessment guides.

FamilyFarmed.org's On-farm Food Safety Project is creating a tool to assist farmers in creating a personalized on-farm food safety plan based on GAP/GHP and HACCP principles. This tool will be available on the website [www.farmfoodsafetyplan.org](http://www.farmfoodsafetyplan.org) as well as offline.

The tool will be based on a decision tree that asks farmers various questions about their operation. Based on your answers, forms and recommendations for policies will be generated that will provide the basis for meeting the documentation requirements for a comprehensive food safety plan and will help in meeting third party food safety certification should that be of interest.

To illustrate how the tool will work, consider the risks associated with hand harvesting of

produce. There are physical and biological hazards associated with foreign material from equipment and from employee health and hygiene practices. The online tool will first ask the user if they hand harvest. If the answer is no, then the tool will move onto the next area (such as machine harvesting). If the answer is yes, further applicable questions will be asked such as do you have a procedure and schedules for equipment sanitation or a training program in place on worker health and hygiene?

Depending on the answers to these questions, the tool will, for example, direct you to comprehensive training materials to assist with training your employees in good health and hygiene practices such as correct handwashing techniques and frequencies, best practice for the use of gloves and what to do in the event of worker illness or injury to ensure both food safety and worker health. Next, it will recommend that you have a written policy in areas such as: what to do in the event of worker illness or injury or in the event of field/produce contamination with blood or bodily fluid; employee practices related to smoking, eating and drinking in the field; and use of hair nets/coverings, clothing and jewelry etc. Use these recommendations and best practices to generate policies appropriate to your operation. Finally, the tool will generate illness/injury report forms and a form that documents that worker health and hygiene training has been undertaken as a corrective action.

The goal is to help farmers reduce the time and learning curve required to generate a personalized food safety plan.

### **GAP/GHP Audit Checklist<sup>40</sup>**

The USDA Agricultural Marketing Service developed the GAP/GHP Audit program

in 2001, following requests from the food industry and state agriculture departments. The program is voluntary, and certifies that growers follow a set of generally accepted agricultural and handling practices, as well as maintain records of those practices. However, as a result of growing public and private concerns about food safety, most larger wholesale buyers and a growing number of smaller purchasers require that farmers receive GAP/GHP certification. They will sometimes request third-party certification programs other than the USDA's, and/or extra requirements for leafy greens. Other major certifying organizations include Primus Labs, NSF Davis Fresh and AIB International.

To find a list of GAP auditors go to <http://del.icio.us/GAPsNET/Third-Party-Audit>

Once onsite, an auditor will utilize a GAP/GHP Audit Checklist going over the same potential risks outlined above. Auditors are reminded to watch for “disqualifiers” that would automatically result in a rating of “Unsatisfactory” for the operation being inspected.

### **Disqualifiers under GAP/GHP**

Conditions under which an automatic “Unsatisfactory” will be assessed:

- An immediate food safety risk is present when produce is grown, processed, packed or held under conditions that promote or cause the produce to become contaminated
- The presence or evidence of rodents, an excessive amount of insects or other pests in the produce during packing, processing or storage
- Observation of employee practices (personal or hygienic) that have jeopardized or may jeopardize the safety of the produce



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- Falsification of records
- No documented food safety program that incorporates GAP and/or GHP
- No person has been designated to implement and oversee an established food safety program

An example of the GAP/GHP Audit Checklist used by USDA inspectors when visiting a farm, is available for free the USDA GAP website: <http://www.ams.usda.gov/fv/fpbgapghp.htm>

Using the tools, principles and resources outlined in this manual, you will be able to develop a comprehensive food safety plan which not only addresses the requirements of third party auditors and many wholesale purchasers but will ensure your farm operates using the highest standard of agricultural practices to help minimize food safety risks.

### Resources

“Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables” is freely available online in the “Produce and Plant Products” section at <http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/default.htm>

“Model Code for Produce Safety” compiled by the Association of Food and Drug Officials (AFDO). Currently in press - due for release in early 2010.

“Food Safety Begins on the Farm: A Grower’s Guide” is freely available at: <http://ecommons.library.cornell.edu/handle/1813/2209>

“Food Safety Begins on the Farm: A grower Self Assessment of Food Safety Risks” available at [https://www.nysaes.cornell.edu/store/catalog/product\\_info.php?products\\_id=44](https://www.nysaes.cornell.edu/store/catalog/product_info.php?products_id=44)

Postharvest Technology Research and Information Center: <http://postharvest.ucdavis.edu>

“Key Points of Control and Management of Microbial Food Safety: Information for Growers, Packers, and Handlers of Fresh-Consumed Horticultural Products” freely available at: <http://anrcatalog.ucdavis.edu/pdf/8102.pdf>

“FSP4U A Food Safety Plan (Template) for You”, freely available at <http://safety.cfans.umn.edu/pdfs/FSP4U.pdf>

FamilyFarmed.org’s On-farm Food Safety Project: [www.farmfoodsafetyplan.org](http://www.farmfoodsafetyplan.org) (this site is in development)

For a comprehensive set of resources on food safety, go to <http://www.gaps.cornell.edu/weblinks.html>

# WHOLESALE SUCCESS Section 8: Crop Profiles

## Introduction to Crop Profiles

The crop profiles listed here contain detailed postharvest information. This includes general harvest tips, quality descriptions, packaging standards, storage conditions, and the most common postharvest pests and diseases. Much of this information comes directly from the USDA.

[www.ba.ars.usda.gov/hb66/contents.html](http://www.ba.ars.usda.gov/hb66/contents.html)

For information about grade standards, please see USDA website [www.ams.usda.gov/AMSV1.0](http://www.ams.usda.gov/AMSV1.0). Follow the “Grading, Certification and Verification” link in the gray textbox on the left. Select “Standards” link under “Services Provided” on the subsequent page. This will

pull up a page outlining “Quality Standards by Commodity”. Follow the “Fresh Fruits and Vegetables (including Fresh Fruits and Vegetables for Processing)” link to locate grade standards for your commodity.

## Contributing Farmers

Farmers with expertise in growing crops for wholesale markets also contributed to many profiles – their input is printed in italicized text to differentiate it from USDA advice. The farmers who helped compile this information include Atina Diffley, Linda Halley, Jim Koan, and Paul Thelan. Any other references used have been marked numerically and are outlined in the reference list for the section.



## Apples



### HARVEST

Quality: Avoid bruised fruit and unripe (lack of flavor) or overripe (mealy) apples.

Harvest tips:

- Use Brix test for sweetness, a starch index, and a pressure test. These are indicators of ripeness (depending on variety), and can also be useful information that a buyer may want before agreeing to buy your apples.
- Twist apples to harvest instead of pulling straight down.
- Water flumes used for conveying fruit should have sanitized water slightly warmer than the apples.
- Computerized sorting systems give the ability to sort by specific sizes and colors.

### HANDLING/PACKING

Grades: Dec. 19, 2002

- **U.S. Extra Fancy:** Clean, mature but not over-ripe, fairly well formed. Apples of this grade must be free of the following: decay, internal browning and breakdown, soft scald, scab, freezing injury, visible water core, broken skins, injury from bruises, brown discoloration, russeting, sunburn or spray burn, limb rubs, hail, drought spots, scars, disease, insects, bitter pit, Jonathan spot, stem cracks. Furthermore, apples must be free of invisible water core damage after January 31, except for the Fuji variety. Tolerance: 10% (5% for serious damage, and 1% for decay).
- **U.S. Fancy:** Same as U.S. Extra Fancy, with differences in color uniformity.
- **U.S. No. 1:** Same as U.S. Fancy, except for color, russeting and water core.
- **U.S. No. 1 Hail:** Same as U.S. No. 1, except that hail marks where the skin has not been broken and well healed hail marks where the skin has been broken, are permitted, provided the apples are fairly well formed.
- **U.S. Utility** (also known as U.S. No. 2): Same as U.S. No. 1, except apples do not have to be fairly well formed, only not seriously deformed.
- **Combination Grades:** Any "adjacent" pairings are allowed (e.g. U.S. Extra Fancy and U.S. Fancy, but not U.S. Fancy and U.S. Utility), such that at least 50% of the apples meet the requirements of the higher grade.

Cooling: Cool apples as quickly as possible to 32-36°F (depending on variety. For Honeycrisp you should store around 60F for a week before cooling to 36°F).

- Forced-air cooling

Washing: Apples can be brushed (to polish) or washed.

Waxing: Apples can be waxed to improve shelf life. There are approved waxes for organic production.

## Apples

### Carton sizes:

#### **Weights:**

- 1 bu. cartons (weight depends on variety)
- 40-lb. cartons w/ 8 5-lb. bags
- 36-lb. cartons w/ 12 3-lb. bags
- 3-, 5-, 6-, 7-, 8-, or 10-lb. PETE/cello bags
- Tri-wall bins
- 600-lb. tote bin / 300-lb. half tote bin (with bags)

#### **Counts:**

- Extra-large: 48, 56, 64, or 72
- Large: 80, 88, or 100
- Medium: 113, 125, or 138
- Small: 150, 163, 175 (no fruit smaller than 175/ct. is marketed fresh)

#### **Diameters:**

2 ¼" – 198; 2 ½" – 175; 2 ⅝" – 138; 2 ¾" – 125; 3" – 100; 3 ½" – 80.

Materials: Apples are most often packed on soft fiberboard trays made from recycled newspaper, or sometimes soft polystyrene. Cartons are often unvented, but this slows the rate of cooling which is detrimental to the longevity of the fruit; as a result, vented cartons are starting to become more common.

### **STORAGE**

- Temperature: 32°F-34°F (0-1.1°C).
- Humidity: 80-90% (higher humidity would require misting which would encourage disease)
- Respiration: 1-3 mL/kg hr at 0°C (32°F)
- Air composition: Varies by apple variety. In general <5% CO<sub>2</sub>, 1.5-4.5% O<sub>2</sub> but check for your specific variety. Fuji, Braeburn and Granny Smith varieties do best when O<sub>2</sub> is reduced only after the apples are chilled to their storage temperature, and when CO<sub>2</sub> is kept lower than O<sub>2</sub>. MCP is also becoming more commonly used, although this is not permitted in organic production. Ethylene scrubbing is also sometimes used.
- Ethylene producer: Yes; 2-12 µL/kg·hr at 32°F (0°C)
- Damage potential: Freezing injury, bruising
- Shelf life: 90-240 days (with refrigeration)

### **PESTS/DISEASES**

Plum curculio

Codling moth

Corn borer

Apple maggot: At harvest, watch for tiny streaks.

Refer to Michigan State University's Fruit Management Guide for more detail on pests and diseases (can be ordered online at <http://web2.msue.msu.edu/bulletins/intro.cfm>)

## Apricots



### HARVEST

Harvest maturity: Harvest date is determined by the color change of the fruit from green to yellow or orange. Fruit should be picked when firm to avoid subsequent bruising. However, when it is too firm it may not have enough sugar.

Quality: Fruit should be free from defects such as bruising, pit burn, gel breakdown, bacterial spot, and decay.

Harvest tips:

- A Brix test is often used to determine ripeness. Taste-test as well.
- A perfectly ripe apricot – you can hear the pit rattle when you shake it.

### HANDLING/PACKING

Grades: Oct. 28, 1994

- **U.S. No. 1:** Fruits should be mature but not overripe, soft, or shriveled. They should be free of defects such as decay, skin breaks such as cuts or worm holes. They should not have damage from limbrubs, growth cracks, russeting, dirt, scabs, hail, bruises, diseases or insects. Tolerance: 10% (5% for serious damage, 1% for decay)
- **U.S. No. 2:** This grade is similar to U.S. No. 2, but includes a slight tolerance to the damages listed above, as long as the damage is not serious. Tolerance: 10% (1% for decay)

Cooling: Quick cooling to 2-4°C will help prevent ripening and decay. Forced-air cooling is commonly used.

Washing: Washing is not advised for apricots.

Carton sizes:

**Weights:** Tray-packed in single or double layers, or volume-filled. 8-12 pint carton.

**Sizes:** No more than 5% of the apricots by count in each container may vary in size by more than 6 mm when measured at the widest part.

Materials: Harvest into plastic totes. If a packing line belt is used, it should be padded.

### STORAGE

- Temperature: 36°F-39.2°F (2°C-4°C); chilling-injury can occur when fruit is held at 36°F-45.7°F (2.2°C-7.6°C) for long periods.
- Humidity: 80-90%
- Respiration: 2 to 4 mL/kg hr at 32°F (0°C)
- Ethylene producer: Yes; <0.1 µL/kg hr at 32°F (0°C)
- Damage potential: Chilling-injury can be avoided by keeping fruit as close to 32°F (0°C) as possible.
- Shelf life: 1-2 weeks (with refrigeration)

### PESTS/DISEASES

Brown rot: Most significant post-harvest disease. Infection occurs during flowering but can affect fruit after harvest.

- Prompt cooling after harvest.

Rhizopus rot: Often occurs in fruit that is ripe or nearly ripe when held at 68°F-77°F (20°C-25°C).

- Cooling after harvest to below 41°F (5°C).

Plum curculio

Bacterial spot

## Artichokes



### HARVEST

Harvest maturity: The outer bracts of an artichoke ready for harvest should be tightly closed, firm and turgid. They are harvested when immature and selected based on size and compactness.

Quality: Will have tightly closed, turgid outer bracts without signs of black tip, blistering or browning. Should be medium to dark glossy green in color and some cultivars may have a magenta color at the base of each bract. Should not be soft when squeezed and should feel heavy for its size.

### HANDLING/PACKING

Grades: Feb. 23, 2006

- **U.S. No. 1:** Smoothly cut stem that is not excessively long. Shall be reasonably firm but not excessively long and pointed. Outer scales may be slightly opened but inner scales at the tip of the artichoke must be closely folded into the bud. Shall not be brownish in color, have scales that are tough, leathery and stringy or have the flower in the center of the bud turning dark pink or purple and becoming fuzzy. Shall be free from decay and not damaged by any other cause. Not more than 10% in any container may vary more than ½" in diameter. Tolerance: 10% (2% for decay).
- **U.S. No. 1 Long Stem:** Meet the requirements of the U.S. No. 1 grade except that stems must be smoothly cut to a minimum length of at least 8", unless otherwise specified. Tolerance (Defects): 10% (2% for decay). Tolerance (Length): 5%.
- **U.S. No. 2:** Shall not be brownish in color, have scales that are tough, leathery, and stringy or have the flower turning dark pink or purple and becoming fuzzy. Shall not be badly spread and shall be free from decay and not seriously damaged by any other cause. Not more than 10% in any container may vary more than ½" in diameter. Tolerance: 10% (2% for decay).

Cooling: Should be pre-cooled to below 41°F (5°C) within 24 hr. of harvest.

- Hydro-cooling
- Forced-air cooling
- Package icing
- Top-icing

Washing: Can be washed in sanitized water if necessary.

Carton sizes:

**Weights:** Classified by the number that fit into a standard carton of about 23 lb eg. size 18 buds (18 buds per carton or >18s).

**Sizes:**

- Small: ≤ 2" diameter
- Medium: 8-10 oz.
- Large: over 15 oz.

# Artichokes

## STORAGE

- Temperature: 32°F (0°C)
- Humidity: >95%
- Respiration: 8-22 mL/kg hr at 32°F (0°C)
- Air composition: 1-6% O<sub>2</sub> and 2-7% CO<sub>2</sub> depending on cultivar. Little or no beneficial effect when buds stored at 32°F (0°C).
- Ethylene producer: Very low. Not very sensitive to ethylene exposure.
- Damage potential: Low
- Shelf life: 14 days

## PESTS/DISEASES

Gray mold: The most common decay found in artichokes. Lesions most frequently begin on wounds and spread to other areas of the bud.

- Store at low temperatures to slow rate of spread.

Bacterial soft rot: May be a problem in storage and distribution if optimum temperature is not maintained.

- Low temperatures must be maintained throughout the cold chain.

## Arugula



### HARVEST

Harvest maturity: Arugula, like lettuce, can be planted after the first frost and harvested in the spring.

Quality: Look for green, smooth, young leaves. Tough leaves with a bitter flavor and furry underside are too old.

Harvest tips:

- Harvest in the morning or the cool part of the day. It's okay if the arugula is still wet – in fact, this is desirable.
- Efficiency tip: harvest into field containers in the same proportions as you will be packing (e.g., Pick 24 at a time if you will be packing 24 to a box).
- Use a field knife to harvest.
- If bunching arugula, it should be bunched in the field. Use twist ties, and tie them high enough that leaves won't fall out and so that retailers can re-trim the bottoms. Trim the bottoms after bunching so they are uniform.
- Should be kept in the shade if not cooling immediately. Should be cooled within 1-2 hours. Having a refrigerated truck in the field or a tank of cold water can help on hot days.

### HANDLING/PACKING

Grades: Arugula is not graded in the U.S.

Cooling: Hydro-cool

Washing:

- Baby arugula: salad machine and spin dry
- Bunched arugula: run through the hydro-cooler and drain upside-down

Materials: Packaging generally consists of fiberboard cartons lined with perforated polyethylene bags, small sealed plastic bags, clamshell containers, or trays. Arugula may also be packaged as a whole plant with roots attached, which can extend the postharvest life. *Bunched arugula should be packaged with 24-30 bunches per box. A bunch is ¾-lb. on average. 1 ⅓ bushel box is generally used. Boxes can be iced (but keep a sheet of paper between ice and arugula). For loose baby arugula, generally 12 4-oz. bags are used.*

### STORAGE

- Temperature: 32-36°F (0-2°C)
- Humidity: 95-100%
- Respiration: 21 mL/kg hr at 32°F (0°C)
- Air composition: Controlled atmosphere generally not beneficial
- Ethylene producer: Very low ethylene production, but highly sensitive to ethylene exposure
- Damage potential: Not sensitive to chilling; should be stored as cold as possible without freezing. *Sensitive to overheating.*
- Shelf life: 7-10 days

### PESTS/DISEASES

Bacterial soft rot and fungal decay: Arugula is prone to the same sorts of postharvest problems as lettuce.

- Postharvest and storage chilling must be maintained to minimize disorders.
- Avoid mechanical damage to leaves.



## Asian Pears



### HARVEST

Harvest maturity: Change in skin color from green to yellowish green (Nijisseiki, Shinseiki, Tsu Li, Ya Li cultivars) or to golden brown (Hosui, Kosui, Niitaka, Shinko cultivars). Fruit should be picked when most of the pears on tree are still green. Delayed harvest results in greater risk of physical injury and increased incidence and severity of physiological disorders. Fruit grown under California conditions and picked later than 180 days (3,000 degree days) after full bloom will likely develop browning during storage as will fruit picked when skin is completely yellow.

Quality: Flesh firmness (penetration force using an 8-mm tip) of 7-10 lb. force depending on cultivar is optimum for eating. Asian pears should be juicy (not mealy) and sweet with 11-14% SSC.

#### Harvest tips:

- Fruit should be held lightly in the palm of the hand and an upward twisting motion used to remove fruit from the spur. A pulling motion can result in damage as the stalk can be removed from the fruit.
- Smooth-surfaced containers such as polystyrene trays, shallow plastic buckets, or plastic trays with foam pads should be used to minimize abrasion and friction marks.
- Fruit should be placed with the stem-end up, preferably in single layers and packed firmly to avoid movement. If packed as two or more layers, care must be taken to avoid stem punctures.

### HANDLING/PACKING

Grades: Asian Pears are not graded in the U.S.

Cooling: Rapid cooling and forced-air cooling are not recommended.

- Room cooling

Washing: Not recommended.

Materials: Store in trays complete with packet pack and polyliners.

### STORAGE

- Temperature: 32°F±2°F (0°C±1°C)
- Humidity: 90-95% (fruit are susceptible to water loss)
- Respiration: 1-4 mL/kg hr at 32°F (0°C)
- Air composition: 1-3% O<sub>2</sub> for some cultivars (eg Nijisseiki) or 3-5% O<sub>2</sub> for others (e.g., Ya Li). Sensitive to CO<sub>2</sub> injury (>2% CO<sub>2</sub> for most cultivars) when stored >1 month.
- Ethylene producer: Some cultivars (such as Nijisseiki, Kosui, and Niitaka) have very low ethylene production. Others such as Tsu Li, Ya Li, Chojuro, Shinsui, Kikusui, and Hosui produce higher levels. Ethylene levels should be kept as low as possible as it may enhance the development of skin browning and fruit senescence.
- Damage potential: Chilling-injury can be a problem with Chinese pear cultivars such as Ya Li, Daisui Li, Seuri, Tse Li, Shin Li and Korean pears, such as Shingo, Okysankichi and Dan Be. Low O<sub>2</sub> injury can occur during longer term storage (e.g., Nijisseiki at ≤ 1% O<sub>2</sub> and Ya Li and Tsu Li pears at ≤ 2% O<sub>2</sub> for 4 months at 32°F).
- Shelf life: 12-20 weeks storage and a subsequent shelf-life of 10-15 days, depending on variety.

# Asian Pears

## **PESTS/DISEASES**

Flesh Spot Decay (FSD): More frequent on large ( $\pm 300\text{g}$ ) and over-mature fruit and can occur in fruit while still on the tree. It is more obvious after 2-6 weeks cold storage. Symptoms include partial browning of spots and/or development of cavities in flesh.

- No effective way to control FSD since definite causes of it have not been identified. Recommend avoiding large fruit, later picking (advanced maturity), extreme temperature changes during the maturation season, sunburn, erratic irrigation or precipitation, harvesting fruit under warm temperatures and cooling fruit rapidly.

Botrytis, Alternaria and Phomopsis pathogens: Invade fruit through wounds causing flesh to become soft and discolored.

- Take care when harvesting to avoid mechanical damage.
- Follow recommended storage conditions.

## Asparagus



### HARVEST

Quality: Closed bracts. Stalks should be 6-10", and should be free of excess woody fiber in the stem. Avoid harvesting spears with a diameter of less than 0.25".

Harvest tips:

- Harvest every 2 days.
- Harvest in the morning or when cool.
- Harvest into clean, sturdy field containers.
- Use a field knife or asparagus tools to harvest.
- Bunch in the packing shed; trim to a uniform height.
- Do not let overheat.
- Fill field containers with cold water while waiting to trim and bunch; this helps to pre-cool.

### HANDLING/PACKING

Grades: Feb. 23, 2006

- **U.S. No. 1:** Fresh, well-trimmed (at least  $\frac{1}{3}$  of the butt of the stalk is smoothly trimmed and is not stringy or frayed), and fairly straight. Free from decay and damage caused by spreading or broken tips, dirt, disease, insects, or other means. The diameter of the stalk must be no less than  $\frac{1}{2}$ ". No less than  $\frac{2}{3}$  of the stalk length must be the same color as the lot. Tolerance: 10% (5% for serious damage, 1% for decay). No more than 10% of the stalks may fail to meet the trimming requirement.
- **U.S. No. 2:** Fresh, fairly well-trimmed, and not badly misshapen. Free from decay and serious damage caused by spreading or broken tips, dirt, disease, insects, or other means. The diameter of the stalk must be no less than  $\frac{5}{16}$ ". No less than half of the stalk length must be the color of the lot. Tolerance: 10% for stalks failing to meet grade requirements, including trimming, diameter, or length requirements. (1% for decay).
  - *Note:* For packages of 50 stalks or less, up to 4 times the standard tolerance is allowed, except that no more than 2 off-size or defective stalks and no more than 1 stalk with decay may be permitted.

Cooling: Immediate cooling after harvest is necessary.

- Hydro-cooling
- Package icing

Washing:

- Soaking in buckets
- Pre-moisten soaking pad

Carton sizes:

**Weights:** Spears trimmed to 7-10" and bundled into 0.75-1-lb. bunches.

- 15-lb. half-pyramid carton

# Asparagus

**Sizes:** By diameter

- Very small:  $< \frac{5}{16}$ "
- Small:  $\frac{5}{16}$ " -  $\frac{1}{2}$ "
- Medium:  $\frac{1}{2}$ " -  $\frac{11}{16}$ "
- Large:  $\frac{11}{16}$ " -  $\frac{7}{8}$ "
- Very Large:  $> \frac{7}{8}$ "

**Materials:** Trapezoidal-shaped crates minimize bending due to gravity. Trimming the butt end of the stalk, and including a wet paper pad in contact with the butt end helps to maintain rigidity. *If asparagus containers are unavailable, asparagus should be packaged upright, and should sit on a moist pad.*

## STORAGE

- Temperature: 32°F-35.6°F (0°C-2°C)
- Humidity: 95-99%
- Respiration: 20-40 mL/kg hr at 32°F (0°C)
- Air composition: 5-10% CO<sub>2</sub>, >2% O<sub>2</sub>
- Ethylene producer: Yes; 2.1-3.1 μL/kg hr at 68°F (20°C). Prompt cooling and maintenance of optimal shipping temperatures can prevent ethylene-induced toughening.
- Damage potential: Chilling-injury, spear toughening, feathering, elongation and tip bending. Do not let overheat.
- Shelf life: 14-21 days (with refrigeration)

## PESTS/DISEASES

**Bacteria soft rot:** Decay occurs as soft rot "pits".

- Store asparagus at lower than 41°F (5°C)

## Atemoya



### HARVEST

Quality: Being a hybrid between sweetsop and cherimoya, Atemoya fruit should be heart shaped and preferably have smooth cherimoya like skin, rather than the bumpy sweetsop skin type. Besides shape, size and skin texture, the fruit should be free of blemishes and mechanical injury that can lead to skin blackening.

Harvest tips:<sup>1</sup>

- Carefully clip from branches, leaving a small portion of the peduncle.

### HANDLING/PACKING

Grades: Atemoya is not graded in the U.S.

Cooling:

- Room cooling
- Forced-air cooling

Carton sizes: Single layer 10-lb. (4.5kg) or 20-lb. (9kg) fiber board boxes with foam sleeves or paper wrapping.

Weights:

- 9-18 oz. (250-500g) are used.

### STORAGE

- Temperature: 50-55.4°F (10-13°C)
- Humidity: 90-95%
- Respiration: 25-100 mL/kg hr at 50°F (10°C)
- Air composition: No published information
- Ethylene producer: High (up to 100-300 µL/kg hr at 68°F [20°C]). Ripening is accelerated by exposure to 100 µL/L for 24 hrs.
- Damage potential: Very sensitive to chilling-injury with skin darkening and loss of aroma and flavor.
- Shelf life: 4-6 weeks (based on cherimoya heritage)

### PESTS/DISEASES

Anthracnose: Appears as dark lesions and may produce pink spore masses under high RH conditions.  
Other decay mechanisms: *Phomopsis* rot and *Rhizopus* have been recorded.

## Avocados



### HARVEST

**Harvest maturity:** Can be held on the tree for many months after they are mature as they do not ripen until harvested. However, time-to-ripen decreases with increasing time on the tree. Freshly harvested avocados tend to have “green” skins although Hass fruit that are harvested late in the season may have some skin darkening. The peel of ripe Hass and Lamb Hass avocados should have a dark, purple-black or black skin while green-skinned cultivars remain green when ripe. Avocados are ripe when the fruit yields slightly to light finger pressure.

**Quality:** Avocado fruit % dry matter (which is highly correlated to fruit oil content) is the key maturity index used. Minimum % dry matter ranges from 17-25%, depending on cultivar. The major quality criteria used during grading are size, skin color, and freedom from wounds, blemishes, insect damage, spray residues (most commonly copper) and other contaminants on the skin. When ripe, the key issues are absence of disease (body rot and stem-end rots), flesh graying and bruising.

#### Harvest tips:

- Harvesting should not be carried out in the rain or when fruit is wet, and careful handling minimizes skin damage which will help to reduce rots. Snap picking of fruit can reduce stem-end rot incidence in dry periods but it can result in increased rots in humid growing environments or when harvested in wet conditions.

### HANDLING/PACKING

**Grades (Florida):** Sept. 03, 1957

- **U.S. No. 1:** Similar varietal characteristics that are mature but not overripe (flesh soft or discolored), with normal shape and color characteristic of the variety, shall be clean with the stem cut off fairly smoothly at a point not more than  $\frac{1}{4}$ ” beyond the shoulder of the avocado, free from decay, Anthracnose, and freezing injury and free from damage caused by bruises, cuts or other skin breaks, pulled stems, russeting, or similar discoloration, scars or scab, sunburn, sunscald or sprayburn, cercospora spot, other disease, insects, or mechanical or other means. Tolerance: 10% (5% for decay or Anthracnose and 1% for decay).
- **U.S. Combination:** Combination of U.S. No. 1 and U.S. No. 2 avocados, provided at least 60 % of the avocados in each container meet the requirements of the U.S. No. 1 grade. Tolerances: 10% failure to meet U.S. No. 2 grade requirements. No part of any tolerance shall be allowed to reduce for the lot as a whole the percentage of U.S. No. 1 fruit required, but individual containers may have not more than 10% less than the percentage of U.S. No. 1 fruit required.
- **U.S. No. 2:** Same as U.S. No. 1, but can be fairly normal in shape and color characteristic of the variety and are free from “serious damage” caused by Anthracnose, bruises, cuts or other skin breaks, etc. as outlined in U.S. No. 1 grade above. Tolerance: 10% (5% for decay or Anthracnose and 1% for decay)
- **U.S. No. 3:** Similar varietal characteristics, mature but not overripe, not badly misshapen, and are free from decay and serious damage caused by Anthracnose. Also free from very serious damage caused by freezing injury, bruises, cuts, or other skin breaks, pulled stems, russeting or similar discoloration, scars or scab, sunburn, sunscald or sprayburn, cercospora spot, other disease, insects, dirt, mechanical or other means. Tolerance: 10% (2% for decay).
- **Unclassified**

## Avocados

**Cooling:** Carried out as rapidly after harvest as possible.

- Forced-air
- Passive air
- Hydro-cooling

**Washing:** Dry brush to clean.

**Carton sizes:** California avocados are packed in single-layer 12.5-lb. (5.67kg) flats or trays (single-layer), 2-layer 25-lb. (11.34kg) lugs and 25-lb. (11.34kg) volume-fill boxes. Common packages used for Florida avocados are: single-layer, 13-lb. (6.12kg) flats, 2-layer, 27-lb. (12.47kg) lugs, 35-lb (15.88kg) cartons and 10-lb. (4.54kg) natural packs.

**Weights (Florida):**

- The “Standard Pack” shall be fairly tight with the weight of the smallest fruit in any container not less than 75% of the weight of the largest fruit in the container. Not more than 5% of the avocados in any container may weigh less than 75% of the weight of the largest fruit, provided that no fruit in any container shall weigh less than 60% of the weight of the largest fruit in the container. In addition, not more than 5% of the containers in any lot may fail to meet the requirement for tightness of pack

**Sizes (Florida):**

- May be specified by count. Commonly used counts are 6, 7, 8, 9, 10, 12, 14, 16, 18, 20, and 24 count.

**Weights and sizes (California):**

- Sized into the following categories: 20 (18.75-22.0-oz.; 532-624g); 24 (15.75-18.75-oz.; 447-532g); 28 (13.75-15.75-oz.; 390-447g); 32 (11.75-14.0-oz.; 333-397g); 36 (10.5-12.5-oz.; 298-354g); 40 (9.50-11.50-oz.; 269-326g); 48 (7.50-9.50-oz.; 213-269g); 60 (6.25-7.50-oz.; 177-213g); 70 (4.75-6.25-oz.; 135-177g); and 84 (3.75-4.75-oz.; 106-135g) count for 25-lb packs, and half these values for flats (or single layer trays).

**Materials:** RPCs (Returnable Plastic Containers), pre-packed units such as polyethylene containers and mesh bags are all increasingly being used.

## Avocados

### STORAGE

- Temperature: For unripe avocados 41-54°F (5-12°C). For Hass variety: 41-44.5°F (5-7°C) for early season fruit and 40-42°F (4-5.5 °C) for late season fruit
- Humidity: 85-95%
- Respiration: 10.5-26.3 mL/kg hr at 41°F (5°C)
- Air composition: 2-5% O<sub>2</sub> (or possibly as high as 10%) and 3-10% CO<sub>2</sub> are used
- Ethylene producer: Low for unripe avocados but increases rapidly after harvest (up to levels >100 µL/kg h at 68°F (20°C) when fully ripe). Very sensitive to ethylene and should not be stored near produce that produces more than trace amounts. Ethylene treatment can be used to accelerate ripening for retail markets.
- Damage potential: Increased risk of chilling disorders (internal and external), uneven ripening and rots result from sub-optimal storage temperatures. Low O<sub>2</sub> injury can also occur with CO<sub>2</sub> atmospheres above 10% potentially leading to discoloration of the skin and off-flavor.
- Shelf life: 2-4 weeks

### PESTS/DISEASES

Various Decay Mechanisms: causing stem-end rot and body rots.

- Good orchard sanitation (removal of mummified fruit and dead wood).
- Pre-harvest fungicide application such as copper in humid growing conditions (e.g., Florida).
- Follow harvest tips.
- Optimize temperatures during handling, storage, transport and ripening.
- Do not store fruit for long periods (1-3 weeks for Hass variety).



## Bananas and Plantains



### HARVEST

**Harvest maturity:** Harvest while mature green and transport to destination markets where they are ripened under controlled conditions (bananas), and controlled or natural conditions (plantains). Plantains tend to mature more prematurely than bananas when harvested at the same age. One criteria for harvesting fruit is age of bunch after emergence from the pseudostem (“emergence” being the day on which the first complete hand of fruit is visible). Fruit size (finger diameter and length), and finger fullness (angularity) are also suitable measures of harvest maturity. At a given age, the maturity of hands in a stem varies, those hands at the proximal end of the stem being more mature than those at the distal end. An estimate of maturity of the entire stem is assessed using the second hand from the proximal end. It is usual to measure length/diameter of the middle finger on outer whorls of the second hand on the stem before running fruit through packing plant processes.

**Quality:** Very clean (free from defects e.g., scars, physical damage, insect injury and latex staining), free from decay, has adequate finger length and diameter, does not have excess curvature and upon ripening, has the desired uniform bright yellow color and sensory attributes in flavor (sweetness, acidity) and aroma.

### Harvest tips<sup>2</sup>:

- Bunches may be covered with polyethylene bags to protect bananas from leaf scarring and to keep dust off.
- Different-colored ribbons can be used each week to record bunch age.

### HANDLING/PACKING

**Grades:** Bananas and plantains are not graded in the U.S.

**Cooling<sup>2</sup>:** Cooling is not initiated until fruit are loaded into containers or cargo holds.

**Washing<sup>2</sup>:** Can be washed in sanitized water to remove latex and reduce staining.

**Carton sizes:** Minimum acceptable size (length and diameter) grade standards for export markets vary depending on banana and plantain cultivar and market specifications. Bananas are packed in corrugated fiberboard boxes as whole hands, clusters or individual fingers and plantains are packed as individual fingers.

### Weights:

- Premium bananas: 28-40-lb. (13-18kg) boxes
- Plantains: 40-lb. boxes

**Materials:** Polyethylene film liners and paper pads to reduce moisture loss and provide protection to fruit from physical damage during handling and transport.

# Bananas and Plantains

## STORAGE

- Temperature: green bananas 56-58°F (13.3-14.4°C), green plantains 48-53°F (8.9-11.7°C)
- Humidity: 90-95%
- Respiration: 10.7-42.8 mL/kg hr at 56°F (13°C)
- Air composition: 2-5% O<sub>2</sub> and 2-5% CO<sub>2</sub>
- Ethylene producer: Low but very sensitive to ethylene exposure. Ethylene (in conjunction with temperature and RH levels) is used for “controlled ripening” of commercial bananas.
- Damage potential: Possible chilling-injury from exposure to temperatures below 56°F (13°C)
- Shelf life: 1-4 weeks

## PESTS/DISEASES

Crown rot: Organisms normally enter after harvest, usually as a result of mechanical injury.

Stem-end rot: Invaded flesh becomes brown, soft and water-soaked.

Cigar-end rot: Rotted tip of the finger is dry and appears similar to the ash of a cigar.

Sigatoka disease: Premature ripening, buff-colored pulp, and increased susceptibility to chilling-injury.

Anthraxnose: Occurs in the plantation. Can appear on green fruit but is more apparent in ripening fruit as numerous small, dark, circular spots.

- Strict sanitation in plantation and packing plant.
- Postharvest treatment with systemic fungicide.
- Minimize mechanical damage during handling.
- Prompt cooling of fruit to lowest safe temperature.
- Expedite transport to final destination.

## Basil



### HARVEST

Quality: Uniformly sized fresh, green leaves with strong aroma and flavor. No yellowing, decay, or insect damage. Generally basil should be harvested before flowering, although a small amount of flowering is acceptable.

Harvest tips:

- *Harvest when free of dew, so that dirt doesn't adhere.*
- *Preferably harvest when clean, so that washing is not needed.*
- *Harvest into clean, sturdy field totes.*
- *Cut with scissors and bunch with a twist tie.*
- *Harvest regularly to inhibit flowering.*

### HANDLING/PACKING

Grades: Basil is not graded in the U.S.

Cooling: Basil should be cooled to no lower than 54°F (12°C).

Washing: Never ice or wash.

Materials: Bunch with rubber band, package in plastic bags or clamshells, pack in corrugated cartons. Perforated polyethylene liners will prevent dehydration and maintain quality. *Use waxed boxes, lined with plastic. In the cooler, cover with a blanket to avoid overcooling. Bunch size should be 2-8-oz.; check with buyer. Use clamshells for a longer shelf life.*

### STORAGE

- Temperature: 54°F (12°C) is the lowest safe temperature
- Humidity: 95-100%
- Respiration: 37 mL/kg hr at 50F (10°C)
- Air composition: 4-6% CO<sub>2</sub>, 5-10% O<sub>2</sub>
- Ethylene producer: Low. Very sensitive to ethylene exposure.
- Damage potential: Very high from chilling-injury
- Shelf life: 7 days

### PESTS/DISEASES

Mold and bacterial decay: Can occur especially where stems or leaves are mechanically cut.

- Low temperatures can prevent this, although this increases the risk of chilling-injury.

## Beans, Green and Snap Varieties



### HARVEST

Harvest maturity: Average time until maturity is 50-60 days and usually 15-18 days following full bloom of the plants flowers.

Quality: Well-formed turgid and straight pods that are bright in color and are tender. The bean cavity should be full. Seeds that are too large or pods that are fibrous are too old to harvest.

Harvest tips:

- Harvest every 2-4 days.
- Do not harvest when wet.
- Dump field containers directly into boxes for shipping.
- Keep stem-ends intact when picking.
- Make sure the beans don't get too hot or too cold.
- Beans can handle being warm much more than other crops.

### HANDLING/PACKING

Grades: Jul. 5, 1990

- **U.S. Fancy:** Reasonable and uniform size, well formed, clean, brightly colored, fresh, tender, firm, free from soft rot and damage. Tolerance: 10% (5% for serious damage, 3% for broken beans, and 1% for soft rot)
- **U.S. No. 1:** Same as U.S. Fancy, but can be of non-uniform size, and can be fairly well formed, fairly bright and fairly tender. Tolerance: 13% (10% for defects other than broken beans, 5% for serious damage, and 1% for soft rot).
- **U.S. No. 2:** Fairly fresh, not over mature, fresh, firm, and free of disease and damage. Tolerance: 15% (10% for serious defects other than broken beans and 1% for soft rot).

Cooling:

- Hydro-cooling
- Forced-air

Washing: *Washing is not needed if clean green beans are picked by hand.*

Carton sizes:

**Weights:**

- 25-lb. 1 <sup>1</sup>/<sub>9</sub> bushel box or green bean bushel box

### STORAGE

- Temperature: 41-46°F (5-7.5°C)
- Humidity: 95-100%
- Respiration: 33 mL/kg hr at 41°F (5°C)
- Air composition: 3-10% CO<sub>2</sub> and 2-5% O<sub>2</sub>
- Ethylene producer: Very low. Sensitive to ethylene exposure.
- Damage potential: Chilling-injury
- Shelf life: 8-12 days

### PESTS/DISEASES

Various decay mechanisms: Common sources are fungi that cause "nesting decay," gray mold, and watery soft rot.

- Avoid overchilling which results in chilling-injury.
- Avoid wetting beans, since surface moisture can encourage decay.
- Avoid mechanical damage.

## Beets



### HARVEST

Harvest maturity: Fresh market bunched beets (with tops) are harvested as early as 50-70 days after planting whereas roots (without tops) are usually harvested later, but before they reach full maturity, especially when they are intended for long-term storage.

Quality: Quality criteria include root shape, root size (diameter), color, firmness (turgidity), smoothness, cleanness, trimming of rootlets, and freedom from defects. Intense and uniform color with minimum zoning is the most important quality criteria.

Harvest tips:

- *Top and tail beets in the field with a field knife. Leave at least 1/2" of the long root.*
- *Bunched beets can be bunched in the field with twist ties. They should be 1-1 1/4 lb. per bunch, with 3-5 beets.*
- *Remove yellow leaves in the field.*
- *Leave bunched beets in tank of cold water or in refrigerated truck while waiting to be cooled.*
- *Bunched stems should fit between thumb and index finger held in a circle.*

### HANDLING/PACKING

Grades: Aug. 1, 1955

- **U.S. No. 1:** Well trimmed, firm, fairly smooth, fairly well shaped, fairly clean, free from soft rot and from damage caused by cuts, freezing, growth cracks, disease, rodents or insects, or mechanical or other means. Bunched beets or beets with short-trimmed tops shall have tops that are fresh and free from decay and free from damage caused by discoloration, freezing, disease, insects, or mechanical or other means. No beet shall be less than 1 1/2" long. Tolerance: 10% (5% for serious damage and 1% for soft rot).
- **U.S. No. 2:** Well trimmed, firm, not excessively rough, not seriously misshapen and free from soft rot and from serious damage caused by cuts, dirt, freezing, growth cracks, disease, rodents or insects, or mechanical or other means. Bunched beets or beets with short-trimmed tops shall have tops that are fresh and free from decay and from damage caused by discoloration, freezing, disease, insects, or mechanical or other means. No beet shall be less than 1 1/2" long. Tolerance: 10% (5% for serious damage and 1% for soft rot).

Cooling:

- Room cooling
- Top-icing

Washing: Barrel wash, if topped. *Pressure wash roots only for bunched beets.*

## Beets

### Carton sizes:

### **Weights:**

- 25-lb. 1 <sup>5</sup>/<sub>9</sub> bushel box (waxed) with polyethylene liner.
- Bunched beets 24 bunches per case waxed leafy greens box.
- Storage beets: 44-lb. polyethylene lined crates, or bins of 1100-1320-lb. capacity

### **Sizes:**

- Diameter of not less than 1 1/2"
- Bunches must weigh at least 1.1-lb. (0.5kg) and must contain at least 3 beets.

### **STORAGE**

- Temperature: 32°F (0°C) for bunched beets; 32.9-35.6°F (1-2°C) for topped beets
- Humidity: 98%
- Respiration: 2-3 mL/kg hr at 32F (0°C)
- Air composition: None needed
- Ethylene producer: Very low. Not sensitive to ethylene exposure.
- Damage potential: Low
- Shelf life: 10-14 days for bunched beets; 4-10 months for topped beets (with ventilation or refrigeration)

### **PESTS/DISEASES**

#### Black rot:

- Maintain good air circulation.
- Promote optimal storage conditions.

Gray mold: The most commonly found decay in storage beets

## Blackberries



### HARVEST

**Quality:** Shiny black color (some varieties can have some reddish color remaining, but risk being too acidic), sweet, and firm but not mushy. Chester Thorntons must be harvested when dull black. Berries are not yet ripe if partially colored or too acidic. Berries are overmature when mushy and beginning to ferment.

### HANDLING/PACKING

**Grades:** Feb. 13, 1928

- **U.S. No. 1:** One variety firm, well colored, well developed and not overripe. Free from caps (calyxes), mold, and decay, and from damage caused by dirt or other foreign matter, shriveling, moisture, disease, insects, or mechanical or other means. Tolerance: 10% (5% for serious damage and 1% for mold or decay)
- **U.S. No. 2:** One variety, fail to meet the requirements of the U.S. No. 1 grade but that do not contain more than 10%, by volume, of berries in any lot which are seriously damaged by any cause, including therein not more than 2% for berries that are affected by mold or decay.
- **Unclassified:** Does not imply a failure to meet standards, merely that a grade standard has not been applied, or does not apply (e.g., multiple varieties sold together).

**Cooling:** Forced-air to within 41°F (5°C) within 4 hrs.

**Washing:** Blackberries should not be washed.

**Carton sizes:** 1-pint, 2-pint, or 1-quart vented plastic clamshell containers, packed in units of 12 per carton.

### STORAGE

- Temperature: 31.1-32°F (-0.5-0°C)
- Humidity: > 90%
- Respiration: 9-10 mL/kg hr at 32°F (0°C)
- Air composition: 10-20% CO<sub>2</sub>, 5-10% O<sub>2</sub>
- Ethylene producer: 0.1-2 µL/kg hr; sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 2-7 days

### PESTS/DISEASES

**Gray mold, Brown rot and Rhizopus rot**

- Keep storage conditions optimal (temperature and atmosphere).

## Blueberries



### HARVEST

Quality: Fruit should be fully blue and firm, and free of decay and injury.

### HANDLING/PACKING

Grades: Mar. 20, 1995

- **U.S. No. 1:** Similar varietal characteristics, clean, well colored, not overripe, crushed, split, leaking, or wet. Fruit should be free from attached stems, mold, decay, insects, mummified berries, clusters, shriveled or broken skin, scars, and green berries. Tolerance: 10% with attached stems, 8% for other defects (4% for serious defects and 1% for mold or decay).
- **Unclassified**

Cooling: Forced-air cooling to <50°F (10°C) within an hour of harvest.

Washing: Blueberries should not be washed.

Carton sizes:

#### Weights:

- 1-or 2-pint vented polyethylene or polystyrene clamshell containers, 12 units to a tray

#### Sizes:

- Extra large: <90 berries/cup
- Large: 90-129 berries/cup
- Medium: 130-189 berries/cup

### STORAGE

- Temperature: 32-37.4°F (0-3°C)
- Humidity: >90%
- Respiration: 1-5 mL/kg hr at 32°F (0°C)
- Air composition: 10-15% CO<sub>2</sub>, 1-10% O<sub>2</sub> for Rabbiteye, Lowbush and Highbush
- Ethylene producer: 0.5-10 µL/kg hr; sensitive to ethylene exposure
- Damage potential: Susceptible to damage during shipping
- Shelf life: 2-4 weeks

### PESTS/DISEASES

Gray mold and ripe rot

Rhizopus stolonifer: Grows readily in fruit packs above 50°F (10°C).

- Pre-cool berries and keep refrigerated during storage.

Blueberry maggot: A primary postharvest pest.

- Methyl bromide applications are the only USDA-approved method of control for quarantine (not organic). This chemical is being phased out in the United States and is highly toxic.
- Entrust is an organic-approved insecticide.



## Bok Choy



### HARVEST

Quality: High-quality bok choy has thick, fleshy, firm stalks and glossy, dark-green leaves. Bok choy with bruised or slimy spots and wilted leaves should be avoided.

Harvest tips:

- Harvest early or when cool; it's good if bok choy is wet.
- Use a field knife to harvest.
- Harvest into a container holding 24 heads.
- Damaged or yellow leaves should be removed.
- Cut above ground to keep knife clean and remove only the good portion; a good picker will not have to re-trim.
- Wipe field knife on pants between each cut.
- Be careful not to handle roughly; bok choy can be bruised.
- Cut open several heads to make sure there is no tip burn (brown on edges of internal leaves).

### HANDLING/PACKING

Grades: Bok choy is not graded in the U.S.

Cooling:

- Hydro-cooling
- Room cooling
- Top-icing

Washing: Wash in water tank with sanitizer; drain upside down

### STORAGE

- Temperature: 32-41°F (0-5°C)
- Humidity: >95%
- Respiration: 2.5-3 mL/kg hr at 32°F (0°C)
- Air composition: 5% CO<sub>2</sub>, 3% O<sub>2</sub>
- Ethylene producer: Very low. Not very sensitive to ethylene exposure
- Damage potential: *Sensitive to overheating*
- Shelf life: 21 days

### PESTS/DISEASES

Leaf yellowing: Occurs during extended storage or at higher than optimal storage temperatures.

- Maintain optimal storage temperatures.

## Broccoli



### HARVEST

Quality: Firm head with buds not open. Central head should be dark blue or green and 4-6" in diameter. Cut main head with 6-8" of stem. Look for good compactness, leafiness, head trim, little damage, and avoid insects and debris. Be sure to harvest in the morning to avoid wilting. Harvest before flower buds are open.

Harvest tips:

- Harvest early, during cool part of day. Broccoli can be wet.
- Can be field packed.
- Bunching broccoli has higher labor costs than shipping main heads.
- Use field knives for harvesting.
- Trim stems and side leaves.
- Summer broccoli can be planted in a field with shade for sweeter broccoli.
- Varieties with high domes that shed water better are preferable.
- 10-14 days before maturity, plants begin to take on a convex shape; insect damage is fine or even beneficial before this stage, but should be controlled once this stage is reached.
- Harvest every 2-4 days.
- Pack so that stem-ends do not damage crowns.
- If care is taken not to dirty broccoli, it will not need to be washed.

### HANDLING/PACKING

Grades: Nov. 2, 2006 Italian sprouting broccoli

- **U.S. Fancy:** (*Very high quality, very difficult to produce, very expensive*) Shall be free from decay and damage caused by overmaturity, discoloration of bud clusters or leaves, freezing, wilting, dirt or other foreign material, disease, insects, or mechanical or other means. The bud clusters shall be generally compact. Bunched broccoli shall be neatly and fairly evenly cut off at the base and closely trimmed unless otherwise specified as well trimmed. Tolerance: 10% (2% for decay)
- **U.S. No. 1:** (*Most broccoli sold for fresh consumption*) Shall be free from decay and from damage caused by overmaturity, discoloration of bud clusters or leaves, freezing, wilting, dirt or other foreign material, disease, insects, or mechanical or other means. The bud clusters shall be generally fairly compact. Bunched broccoli shall be neatly and fairly evenly cut off at the base, and well trimmed, unless otherwise specified as closely trimmed, fairly well trimmed, or leafy. Tolerance: 10% (2% for decay).
- **U.S. No. 2:** Shall be free from decay, and from damage caused by overmaturity, insects, and from serious damage caused by discoloration of bud clusters or leaves, freezing, wilting, dirt or other foreign material, disease, or mechanical or other means. Bunched broccoli shall be fairly well trimmed unless otherwise specified as closely trimmed, or well trimmed, or leafy. Tolerance: 10% (2% for decay).

Cooling:

- Injecting liquid ice into the waxed cartons
- Hydro-cooling
- Forced-air cooling

## Broccoli

Washing: Can be washed in sanitized water if necessary

### Weights:

- Bunched (2-3 heads): 14-18 bunches in waxed cardboard boxes.  
Approx 21 lb (10kg)
- *Main heads 18-20 lb. broccoli box*

### Diameters:

- U.S. Fancy:
  - Bunched: < 2.5"
  - Crowns: 2.5 < diam < 5"
  - Florets: 0.75 < diam < 3"
- U.S. No. 1:
  - Florets: 1-4"

### Length:

- U.S. Fancy:
  - Bunched: <8.5"
  - Crowns: 2.5 < length < 5"
  - Florets: 1 < length < 3.5"
- U.S. No. 1:
  - Bunched: 5 < length < 9"
  - Crowns: 3.5 < length < 6"
  - Florets: 1.5 < length < 4.5"
- U.S. No. 2: No requirements

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 98-100%
- Respiration: 10-11 mL/kg hr at 32°F (0°C)
- Air composition: 5-10% CO<sub>2</sub>, 1-2% O<sub>2</sub>
- Ethylene producer: Very low. Extremely sensitive to ethylene exposure
- *Damage potential: Very high: extremely sensitive to high respiration at warm temperatures*
- Shelf life: 2-3 weeks

### PESTS/DISEASES

#### Cabbage aphid:

- Avoid N<sub>2</sub> levels that are too high or too low.
- Encourage predatory beneficials.

#### Various bacteria and fungal rots: Including gray mold rot, *Erwinia carotovora*, and *Pseudomonas*

- Avoid N<sub>2</sub> levels that are too high or too low.
- Maintain optimal storage temperatures.
- Certain varieties are somewhat resistant to *Pseudomonas*.

## Brussels Sprouts



### HARVEST

Quality: Sprouts are 1-2" in diameter, stems < 2 3/4". Green outer leaves and white cut end. Inner leaves are slightly yellow and tightly arranged.

Harvest tips:

- *Pinch off the top when lower sprouts are 1/2-3/4" in diameter; full stem of uniform-sized sprouts will develop in about four weeks.*
- *Cut off stalk with a knife.*

### HANDLING/PACKING

Grades: Jan. 18, 1954

- **U.S. No. 1:** Well-colored, firm, not withered or burst, free from soft decay and seedstems and from damage caused by discoloration, dirt or other foreign material, freezing, disease, insects, or mechanical or other means. Tolerance: 10% (2% for soft decay)
- **U.S. No. 2:** Fairly well colored, fairly firm, not withered or burst, free from soft decay and seedstems and from damage caused by insects, and free from serious damage caused by discoloration, dirt or other foreign material, freezing, disease or mechanical or other means. Tolerance: 10% (2% for soft decay).
- **Unclassified**

Cooling:

- Forced-air cooling – most effective when pre-moistened

Washing: Not recommended

Carton sizes:

**Weights:**

- 25-lb. (11kg) cartons

**Sizes:**

- Diameter should be 1-2.5".

Materials: Plastic liners are often used in cartons with loose sprouts to reduce moisture loss. In addition, polyethylene bags are sometimes used in place of the plastic containers for consumer units.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-100%
- Respiration: 10-20 mL/kg hr at 32°F (0°C)
- Air composition: 5-10% CO<sub>2</sub>, 1-2% O<sub>2</sub>
- Ethylene producer: 0.25 µL/kg hr, increasing tenfold with prolonged storage. Very sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 3-5 weeks (with recommended refrigeration)

### PESTS/DISEASES

Bacterial soft rot

Bacterial, black or gray leaf spot

Gray mold

## Cabbage



### HARVEST

Quality: Crisp, firm, compact head. Should be easy to harvest, and should not have loose leaves or a head that is cracked open.

Harvest tips:

- *Stands up to heat; harvest any time of day.*
- *Field packing is a good idea, but cabbage must be kept clean.*
- *Harvest leaving 1-2 wrapper leaves.*
- *Wrapper leaves can have insect damage, but main head should not have damage.*
- *Don't ship cabbages that are full of worm excrement.*
- *Cut some cabbages open to check for internal problems.*

### HANDLING/PACKING

Grades: Sep. 1, 1945

- **U.S. No. 1:** One variety or similar varietal characteristics, which are of reasonable solidity, and are not withered, puffy, or burst and are free from soft rot, seedstems, and from damage caused by discoloration, freezing, disease, insects or mechanical or other means. Stems shall be cut so that they do not extend more than  $\frac{1}{2}$ " beyond the point of attachment of the outermost leaves. Tolerance: 10%.
- **U.S. Commercial:** Meet the requirements for U.S. No. 1 grade except for an increased tolerance for defects, and the heads shall be reasonably firm. Tolerance: 25% .

Cooling: Forced-air cooling during storage

Washing: Not recommended

Carton sizes:

**Weights:**

- *45 to 50-lb. in  $1\frac{3}{4}$  or  $1\frac{7}{8}$  bushel waxed cabbage containers*
- Heavy fiberboard bulk pallet bins holding 500-1000 lb.

**Sizes:** (Classification optional)

Pointed (oxheart) cabbage:

- Small: < 1.5 lb.
- Medium: 1.5-3 lb.
- Large: > 3 lb.

Domestic and Danish (green) types:

- Small: < 2 lb.
- Medium: 2-5 lb.
- Large: > 5 lb.

# Cabbage

## STORAGE

- Temperature: 32°F (0°C)
- Humidity: 98-100%
- Respiration: 2-3 mL/kg hr at 32°F (0°C)
- Air composition: 4-5% CO<sub>2</sub>, 2-3% O<sub>2</sub>
- Ethylene producer: Low. Sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 1-6 months

## PESTS/DISEASES

Gray mold fungus: A major cause of postharvest decay.

- Use less susceptible cultivars.
- Use preharvest fungicides.
- Practice strict hygiene.
- Avoid mechanical or frost damage.
- Perform rapid cooling to 32°F (0°C).
- Maintain a controlled atmosphere.

Alternaria rot (dark, black or gray leaf spot): Infects a wide range of cruciferous crops.

- Use preharvest fungicides.
- Destroy diseased material before storage.
- Perform rapid cooling to 32°F (0°C).

## Cantaloupe

### HARVEST

Harvest maturity: *Most varieties should be harvested at half slip, when the fruit leaves the vine with a gentle tug. Honeydews and casabas don't slip. They must be cut. Change from green to yellow in rind background color for netted cantaloupe. Blossom end should be firm.*

Quality: If picked at proper maturity, netted melons will continue to soften and become more aromatic after harvest. Avoid exposure to sun or high temperatures when harvesting.

Harvest tips:

- *Harvest daily or every other day.*



### HANDLING/PACKING

Grades: Mar. 10, 2008

- **U.S. Fancy:** Meets the requirements of U.S. No. 1 grade except that the cantaloupes have very good internal quality and have uniform appearance. Tolerance: Defects at shipping point: 8% (4% for serious damage, 0.5% for decay or mold). Defects en route or at destination: 12% (8% for permanent defects, 6% for serious damage, 4% for serious damage by permanent defects and 2% for decay).
- **U.S. No. 1:** Mature and have good internal quality but are not overripe or soft or wilted, are well formed, well netted, and free from decay, wet slip and sunscald and free from damage caused by liquid in the seed cavity, sunburn, hail, dirt, surface mold or other disease, aphid or other insects, scars, cracks, sunken areas, ground spot, bruises, or mechanical or other means. Tolerance: Defects at shipping point: 8% (4% for serious damage, 0.5% for decay or mold). Defects en route or at destination: 12% (8% for permanent defects, 6% for serious damage, 4% for serious damage by permanent defects and 2% for decay).
- **U.S. Commercial:** Mature but not overripe or soft or wilted, are well formed and fairly well netted, and free from decay, wet slip and sunscald and free from damage caused by liquid in the seed cavity, sunburn, hail, dirt, surface mold or other disease, aphid or other insects, scars, cracks, sunken areas, ground spot, bruises, or mechanical or other means. Tolerance: Defects at shipping point: 16% (12% for condition defects, 4% for serious damage, 0.5% for decay or mold). Defects en route or at destination: 24% (16% for permanent defects, 12% for condition defects, 8% for serious damage, 4% for serious damage by permanent defects and 2% for decay).
- **U.S. No. 2:** Mature but not overripe or soft or wilted, are fairly well formed and fairly well netted, free from decay, wet slip and sunscald and free from serious damage caused by liquid in the seed cavity, sunburn, hail, dirt, surface mold or other disease, aphid or other insects, scars, cracks, sunken areas, bruises, or mechanical or other means. Tolerance: Defects at shipping point: 8% (0.5% for decay or mold). Defects en route or at destination: 12% (8% for defects of a permanent nature and 2% for decay).
- **Unclassified**

Cooling:

- Forced-air cooling

Washing: *Dry brushing in the field, or brush wash if harvested in muddy conditions.*

# Cantaloupe

Carton sizes:

**Weights:** 40-lb. cardboard shipping box

**Sizes:** Number of uniformly sized fruit that fit in a standard 40-lb. box

- 9, 12, 15, 18, 23, 30

Materials: Harvest and packing equipment should be padded to reduce scuffing of netting. Melons are easily injured and should not be dropped.

## **STORAGE**

- Temperature: *40°F if harvested at half slip; 36°F if harvested at full slip*
- Humidity: 95%
- Respiration: 2.5-3 mL/kg hr at 32°F (0°C)
- Air composition: 10-20% CO<sub>2</sub>, 3-5% O<sub>2</sub>
- Ethylene producer: 10-100 µL/kg hr; sensitive to ethylene exposure
- Damage potential: Less mature fruits are more sensitive to chilling-injury
- Shelf life: 10-14 days

## **PESTS/DISEASES**

Fusarium rot: Symptoms vary depending on Fusarium species, but large fissures and an enlarged or thickened, dark-tan net at the lesion site is common. A distinct delineation is apparent between diseased and healthy tissue. There is often no sign of infection prior to harvest, but numerous spongy white lesions may develop internally postharvest.



## Carrots



### HARVEST

**Quality:** Partially mature;  $\frac{1}{2}$ - $\frac{3}{4}$ " at shoulder. Firm, straight from shoulder to tip, smooth with little residual "hairiness," sweet with no bitter or harsh taste, and show no signs of cracking or sprouting.

**Harvest tips:**

- Loosen with a fork or a bed lifter before harvesting.
- Cull hairy carrots – these are bitter.
- Cull forked carrots.

### HANDLING/PACKING

**Grades – Bunched carrots:** Sep. 18, 1954

- **U.S. No. 1:** Similar varietal characteristics, roots that are firm, fairly clean, fairly well colored, fairly smooth and well formed, and free from soft rot and from damage caused by freezing, growth cracks, sunburn, pithiness, woodiness, internal discoloration, oil spray, dry rot, other disease, insects, or mechanical or other means. Bunches shall have tops which are fresh and free from decay and free from damage caused by freezing, seedstems, yellowing or other discoloration, disease, insects or mechanical or other means. Unless otherwise specified, the bunches shall have full tops and the length of tops shall be not more than 20". Tolerances: 10% for defects, 25% for off-length tops, 5% for smaller-sized carrots, 10% for larger-sized carrots.
- **U.S. Commercial:** Same as U.S. No. 1, but with an increased (20%) tolerance for root defects.
- **Unclassified**

**Grades – Topped carrots:** Dec. 20, 1965

- **U.S. Extra No. 1:** Similar varietal characteristics and are well trimmed, firm, clean, fairly well colored, fairly smooth and well formed. Shall be free from secondary new top growth and soft rot and free from damage caused by freezing, growth cracks, sunburn, pithiness, woodiness, internal discoloration, oil spray, dry rot, other disease, insects, or other means. Tolerance: 10% (5% for serious damage and 1% for soft rot).
- **U.S. No. 1:** Similar varietal characteristics and are well trimmed, firm, fairly clean, fairly well colored, fairly smooth and fairly well formed. Shall be free from soft rot and from damage caused by freezing, growth cracks, sunburn, pithiness, woodiness, internal discoloration, oil spray, dry rot, other disease, insects, or other means. Tolerance: 10% (5% for serious damage and 2% for soft rot).
- **U.S. No. 1 Jumbo:** Same as U.S. No. 1 except for size.
- **U.S. No. 2:** Similar varietal characteristics which are well trimmed, firm, not excessively rough, and not seriously misshapen. Shall be free from soft rot and from serious damage caused by dirt, freezing, growth cracks, sunburn, pithiness, woodiness, internal discoloration, oil spray, dry rot, other disease, insects, or other means. Tolerance: 10% (2% for soft rot).
- **Unclassified**

**Grades – Short trimmed tops:** Sep. 18, 1954

- **U.S. No. 1:** Similar varietal characteristics, roots that are firm, fairly clean, fairly well colored, fairly smooth, well formed, and that are free from soft rot and free from damage caused by freezing, growth cracks, sunburn, pithiness, woodiness, internal discoloration, oil spray, dry rot, other disease, insects or mechanical or other means. The carrots shall have leaf stems that are free from decay and free from damage caused by freezing, seedstems, yellowing or other discoloration, disease, insects, or mechanical or other means. The leaf stems shall be cut back to not more than 4" in length. Tolerance: 10% for defects, 5% for smaller sized carrots, 10% for larger sized carrots.

## Carrots

- **U.S. Commercial:** Same as U.S. No. 1, but with an increased (20%) tolerance for root defects.
- **Unclassified**

### Cooling:

- Hydro-cooling to less than 41°F (5°C)
- Ice after cooling

Washing: *Barrel wash.*

### Carton sizes:

#### **Weights:**

- 25-lb in  $\frac{5}{9}$  waxed carton with perforated polyethylene liner. Or 50 lb. in 1  $\frac{1}{9}$  bushel

#### **Length:**

- Topped: 5+” (U.S. No. 2: 3+”)

#### **Diameters:**

- Bunched: At least  $\frac{3}{4}$ ”
- Short trimmed tops: At least  $\frac{3}{4}$ ”
- Topped:
  - U.S. Extra No. 1:  $\frac{3}{4}$ ”-1 $\frac{1}{2}$ ”
  - U.S. No. 1:  $\frac{3}{4}$ ”-1 $\frac{1}{2}$ ”
  - U.S. No. 1 Jumbo: 1”-2 $\frac{1}{2}$ ”
  - U.S. No. 2: 1”-3”

### **STORAGE**

- Temperature: 32-33.8°F (0-1°C)
- Humidity: 98-100%
- Respiration: 5-10 mL/kg hr at 32°F (0°C)
- Air composition: Not important. >5% CO<sub>2</sub> and <3% O<sub>2</sub> promotes decay
- Ethylene producer: Very low. Exposure to ethylene causes a bitter flavor
- Damage potential: Low
- Shelf life: 5-6 months

### **PESTS/DISEASES**

Various decay agents: Bacteria soft rot, gray mold rot, Rhizopus soft rot, watery soft rot, and sour rot.

- Ozone is a fungistatic, but tissue damage and color loss occur after treatment.
- Maintain good sanitation.
- Keep storage temperature close to 32°F (0°C).

## Cauliflower



### HARVEST

Quality: White to cream in color, firm, and compact. The curds should be free of mechanical damage, decay, browning, or yellowing, which can be caused by sun exposure. Heads should be surrounded by a whorl of trimmed, green, turgid leaves.

Harvest tips:

- *Tolerates hot or wet harvest conditions.*
- *Cauliflower bruises easily. Additional leaves can be used for cushioning in between layers. Bruises show up a day later – so be careful!*
- *Cauliflower can be field packed.*
- *Use field knife to harvest.*

### HANDLING/PACKING

Grades: Mar. 15, 1968

- **U.S. No. 1:** Basic requirements for curds: clean, compact, color – white, creamy white, or cream; size – not less than 4” in diameter. Basic requirements for jacket leaves: fresh, closely trimmed, unless otherwise specified, fairly clean. Free from soft or wet decay. Free from damage caused by bruising, cuts, discoloration, enlarged bracts, fuzziness, hollow stem, insects, mold, riciness, wilting, and, other means. Free from serious damage by any cause. Tolerance: 10% (5% for serious damage).
- **U.S. Commercial:** Same as for U.S. No. 1, but with increased tolerances. Tolerance: 20% (10% for serious damage).
- **Unclassified**

Cooling:

- Top-ice
- Forced-air cooling

Washing: Wash if necessary.

Carton sizes

**Weights:**

- *Single layer 25-lb. cabbage box*
- *20-lb. 1 1/9 bushel box*

**Sizes:**

- Variation in curd size is not more than 1 1/2” in any individual container.

Materials: *Use leaves to wrap heads, and then buyer will need to trim and plastic wrap. This is called a “green jacket pack”.*

# Cauliflower

## STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-98%
- Respiration: 8-9 mL/kg hr at 32°F (0°C)
- Air composition: Modest benefits. 3-5% CO<sub>2</sub>, <2% O<sub>2</sub> delays leaf yellowing, but low O<sub>2</sub> may cause injury.
- Ethylene producer: Very low. Very sensitive to ethylene exposure
- *Damage potential: Medium*
- Shelf life: Up to 3 weeks (much less if kept warmer than 32°F [0°C])

## PESTS/DISEASES

### Bacterial soft rot and brown rot

- Store only good quality, disease-free heads.
- Maintain good temperature control.

## Celeriac



### HARVEST

Quality: Firm texture and tender flesh. Roots with a soft, spongy texture should be avoided.

Harvest tips:

- *Celeriac can be harvested with tops attached, or tops can be cut off.*
- *Pull by hand; loosen with a fork first if soil is heavy.*
- *Trim roots with a large harvest knife.*
- *Pull off older yellowing stalks.*

### HANDLING/PACKING

Grades: No grading for celeriac in the U.S.

Cooling: Celeriac would benefit from pre-cooling since it retains quality best when stored at 32°F (0°C). However, since celeriac has a relatively low respiration rate, the benefits of pre-cooling must be balanced with the desired storage time before marketing.

Washing: *Pressure wash; allow to dry before packing. Celeriac for storage should have tops removed and should not be washed until after storage.*

Carton sizes:

**Weights:** 1 1/9 bu. box, 24 to a box

Materials: *Boxes should be unlined*

### STORAGE

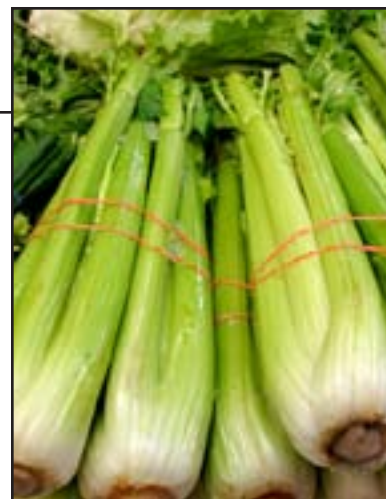
- Temperature: 32-36°F (0-2°C)
- Humidity: 97-98%
- Respiration: 2.5-4 mL/kg hr at 32°F (0°C)
- Air composition: Not very effective; 2-3% CO<sub>2</sub>, 2% O<sub>2</sub>
- Ethylene producer: Low. Somewhat sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 6-8 months

### PESTS/DISEASES

Decay: Can be a problem at warm temperatures.

- Follow recommended storage conditions.

## Celery



### HARVEST

**Quality:** High quality celery consists of petioles that are well formed thick, compact, and straight. Petioles should be tender, light green, and appear fresh. Additional quality indices are: stalk and midrib length, freedom from defects such as blackheart, pithiness, seed stalks, cracks, and absence of insect damage and decay. Any leaves remaining on the stalk after trimming should not be wilted, yellow or decayed.

### HANDLING/PACKING

**Grades:** Apr. 7, 1959

- **U.S. Extra No. 1:** Similar varietal characteristics and are well developed, well formed, clean, well trimmed, compact, and which are free from blackheart, brown stem, soft rot, doubles, and free from damage caused by freezing, growth cracks, horizontal cracks, pithy branches, seedstems, suckers, wilting, blight, other disease, insects, or mechanical or other means. Stalks shall be green unless specified as fairly well blanched, or mixed blanch. The average midrib length of the outer whorl of branches shall be not less than 7". Unless otherwise specified in connection with the grade, stalks shall be of such length as to extend from one side, end, or bottom of the container to within 1 1/2" of the corresponding opposite side, end, or top of the container. Such measurement shall not include the bulge. In any container when stalk length is specified, it shall be the minimum length in terms of whole inches of even number, such as 12", 14", etc. Tolerance: 10% for defects, 5% for off-length stalks, 5% for off-length midribs.
- **U.S. No. 1:** Similar varietal characteristics and are fairly well developed, fairly well formed, well trimmed, fairly compact, and free from blackheart, soft rot, and from damage caused by freezing, growth cracks, horizontal cracks, pithy branches, seedstems, suckers, dirt, doubles, wilting, blight, other disease, insects, or mechanical or other means. Stalks shall be green unless specified as fairly well blanched, or mixed blanch. Unless otherwise specified, the average midrib length of the outer whorl of branches shall be not less than 6". Unless otherwise specified in connection with the grade, stalks shall be of such length as to extend from one side, end or bottom of the container to within 1 1/2" of the corresponding opposite side, end, or top of the container. Such measurement shall not include the bulge. In any container when stalk length is specified, it shall be the minimum length in terms of whole inches of even number, such as 12", 14", etc. Same tolerances as U.S. Extra No. 1.
- **U.S. No. 2:** Similar varietal characteristics and are reasonably well developed, reasonably well formed, fairly well trimmed, and free from blackheart and soft rot, and from serious damage caused by freezing, growth cracks, horizontal cracks, pithy branches, seedstems, dirt, doubles, wilting, blight, other disease, insects or mechanical or other means. Stalks shall be green unless specified as fairly well blanched, or mixed blanch. Same tolerances as U.S. No. 1.
- **Unclassified**

**Cooling:** Prompt pre-cooling to 32°F (0°C) is critical

- Hydro-cooling with chilled water spray

# Celery

Washing: Trim before washing. Barrel wash line with pressure wash at the end.

Carton sizes:

**Weights:**

- 60-lb. cartons with 48 stalks
- 7 size grades with 18-96 stalks per crate
- Celery hearts – (8, 10, or 12" in length) – 18 or 28-lb. cartons

## **STORAGE**

- Temperature: 32°F (0°C)
- Humidity: > 95%
- Respiration: 5-10 mL/kg hr at 32°F (0°C)
- Air composition: 3-5% CO<sub>2</sub>, 2-4% O<sub>2</sub>
- Ethylene producer: Low. Sensitive to ethylene exposure at temperatures above 41°F (5°C)
- Damage potential: Low
- Shelf life: 5-7 weeks (with refrigeration)

## **PESTS/DISEASES**

Pithiness: Caused by pre-harvest as well as storage factors.

- Store at 32°F (0°C).

Bacteria soft rot and gray mold

- Store at 32°F (0°C).

Watery soft rot

- Store at 32°F (0°C).
- Keep atmosphere controlled.

## Chard



### HARVEST

Quality: Leaves must be turgid and dark green, with the midrib and petiole completely white or red depending on the variety. Leaves must not show any symptoms of yellowing or browning, or have soil residues. Harvested leaves with petioles can be 7.5-20" (20-50cm) long.

Harvest tips:

- *Harvest early in the day.*
- *Bunch in the field, at least 4" up the stalk, where leaves start to fill out; 6-8 leaves per bunch.*
- *Don't pick newest leaves – these won't hold up in storage; conversely leaves that are too old are tough.*
- *Stem trimming may be required by some buyers.*

### HANDLING/PACKING

Grades: Chard is not graded in the U.S.

Cooling:

- Hydro-cooling
- Icing

Washing: *Wash via hydro-cooling*

Carton sizes: *Leafy greens or cabbage box; 24 bunches to a box*

Materials: Using plastic films to cover packaging reduces water loss.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-98%
- Respiration: 9-10 mL/kg hr at 36°F (2°C)
- Air composition: 2-3% CO<sub>2</sub>, 10% O<sub>2</sub> (and temperature of 31°F [-0.5°C]) can increase storage to 1 month.
- Ethylene producer: Very low. Very high sensitivity to ethylene exposure.
- *Damage potential: High*
- Shelf life: 1-2 weeks



## Cherimoya



### HARVEST

Harvest maturity: Mature fruit are firm and become very soft during ripening. Skin changes color from dark to light green or greenish-yellow and is associated with increased surface smoothness. Fruit is harvested when mature and allowed to ripen during marketing.

Quality: Fruit size (9-21 oz.), shape and skin color along with the absence of defects and decay are indicators of quality. Fruit are very susceptible to mechanical injury. Sugar levels can vary from 14-18%, with moderate acid levels.

Harvest tips:<sup>3</sup>

- Fruit should be clipped rather than pulled from the tree.
- Cut stem close to fruit so it won't puncture other fruit during storage.

### HANDLING/PACKING

Grades: Cherimoya is not graded in the U.S.

Cooling: Pre-cool as soon as possible after harvest to about 54-59°F (12-15°C)

- Room cooling
- Forced-air cooling

Carton sizes:

**Weights:**

- Carton size 9- and 18-lb. (4 and 8kg) with 12 to 24 count.

**Sizes:**

- 9-21 oz. (250-600g) fruit are used.

Materials: Single-layer pack in fiberboard carton with foam sleeve or paper wrapping to avoid bruising.

### STORAGE

- Temperature: 50-55.4 °F (10-13 °C). Ripe, soft fruit should be held at 32-41 °F (0-5 °C)
- Humidity: 90-95%
- Respiration: 24.7-100 mL/kg hr at 50°F (10°C)
- Air composition: 5% O<sub>2</sub>, 3% or 6% CO<sub>2</sub>. Not all results have been positive and there may be varietal differences.
- Ethylene producer: High. Exposure to 100 µL/L for 24 hrs leads to rapid ripening of mature green fruit
- Damage potential: Potential chilling-injury below 50°F (10°C) results in skin darkening and a failure to fully soften and develop full flavor. O<sub>2</sub> levels <1% can lead to off-flavor.
- Shelf life: 2-3 weeks

### PESTS/DISEASES

Anthraxnose: Appears as dark lesions and may produce pink spore masses under high RH conditions.

Black canker: Appears as purple spots that become hard and cracked.

Botryodiplodia rot: Appears as purple then black spots. Flesh becomes brown and corky.

- Use good orchard sanitation. Careful handling and sanitation with cooling.
- Use fungicides, if approved.

## Cherries



### HARVEST

Quality: Premium sweet cherries have a bright, shiny appearance with fruit color ranging from dark red (Bing), red (Sweetheart) or yellow with a red blush (Rainier and Royal Ann). The presence of a stem that is green and free from brown discoloration is also critical for marketing. Flavor is enhanced by high soluble solids and titratable acid content. A firm, juicy fruit texture is also an indicator of quality.

Harvest tips:

- *If stems stay on when cherries are picked, the cherries are not fully ripe.*

### HANDLING/PACKING

Grades: May 7, 1971

- **U.S. No. 1:** Similar varietal characteristics, mature, fairly well colored, well formed, and clean. Free from decay, insect larvae or holes caused by them, not soft, overripe, or shriveled, no undeveloped doubles or sunscald. Free from damage by any other cause. Tolerance: 8% (4% for serious damage and 0.5% for decay).
- **U.S. Commercial:** Same as U.S. No. 1, except for increased tolerances: 16% (4% for serious damage and 0.5% for decay)

Cooling: Cherries should be cooled to less than 5°C (41°F) by 4 hr after harvest.

- Hydro-cooling
- Room cooling
- Forced-air cooling

Washing: Cherries are not generally washed.

Carton sizes:

**Weights:**

- 20-lb. cartons
- 10-lb. cartons

**Sizes:**

- U.S. No. 1: minimum  $\frac{3}{4}$ " diameter
- U.S. Commercial: minimum  $\frac{5}{8}$ " diameter  
Smaller sizes are becoming available

### STORAGE

- Temperature: 32-36°F (0-2°C)
- Humidity: 80-90%
- Respiration: 3-5 mL/kg hr at 32°F (0°C)
- Air composition: 5-20% CO<sub>2</sub>, 1-5% O<sub>2</sub>
- Ethylene producer: Very low. Sensitive to ethylene exposure
- Damage potential: Pitting and bruising
- Shelf life: 2-4 weeks (with refrigeration)

### PESTS/DISEASES

Various fungal pathogens: Blue mold, gray mold, Alternaria, brown rot, *Rhizopus stolonifer*, *Cladosporium sp.*, and *Aspergillus niger*.

- Avoid injuring fruit during handling.
- Use postharvest sanitation.
- Store at low temperature.

## Coconuts



### HARVEST

Harvest maturity: Young coconuts are harvested 6-9 months after flowering as the nut approaches full size, the skin is still green and the short stem on top of the coconut becomes half green and brown. When the area surrounding the cap is green the coconut is regarded as mature and is 10-12 months old. At maturity the skin begins to change from green to yellow, then brown, and the stem is entirely brown. In immature coconuts, the skin surface around the cap is creamy-white or a whitish-yellow.

Quality: Maturity, size, freedom from blemishes and cracking, freedom from fiber for husked coconuts and wet or moldy eyes. Check for a sloshing sound indicating presence of coconut water in the nut.

### HANDLING/PACKING

Grades: Not graded in the U.S., but informal grades are usually based on size and weight.

Cooling: A rapid temperature change of 14.4°F (8°C) can cause cracking.

- Room cooling (generally used for mature husked nuts)
- Forced-air
- Hydro-cooling

Washing: Not recommended for mature nuts. Young and immature husked coconuts are shaped, dipped into sodium bisulfite and film-wrapped to minimize browning.

Carton sizes: Mature U.S. de-husked coconuts are sold in 75-80 lb. (34-36kg) woven plastic or burlap sacks containing 40-50 coconuts, plastic mesh bags of 12 coconuts or cartons with 20-25 film-wrapped coconuts (37-40 lbs. [17-18kg]). Immature husked coconuts are sold in single piece cartons containing 10-16 nuts.

### Weights:

- Immature, de-husked coconuts are about 4" (10cm) in diameter, weigh about 1.1 lb. (500g), have 3.5-oz. (100g) endosperm, 4.2-oz. (120g) shell and 8.8-oz. (250g) water.

Materials: Mature de-husked coconuts are waxed or film-wrapped to reduce water loss. Immature husked nuts can also be film-wrapped or waxed, however the outside color changes rapidly from white to brown unless dipped in sodium bisulfite.

# Coconuts

## STORAGE

- Temperature: 32-35°F (0-1.5°C) for mature, de-husked coconuts. 37-43°F (3-6°C) for young coconuts
- Humidity: 75-85% for mature, dehusked coconuts, 90-95% for young coconuts.
- Respiration: 26-32  $\mu\text{L} / \text{kg hr CO}_2$  at 77 °F (25°C)
- Air composition: No data available
- Ethylene producer: Very low for mature husked coconuts. Not sensitive to ethylene.
- Damage potential: When stored at 32°F (0°C), the green skins of immature nuts turn brown after 7 days, but few other changes in quality occur.
- Shelf life: Up to 60 days for mature, dehusked coconuts, 3-4 weeks for young coconuts and wrapped, shaped fruit. Mature coconuts with husk can be kept at ambient conditions for 3-5 months. Young coconuts with husk can be stored for a longer period than de-husked or shaped young coconuts.

## PESTS/DISEASES

Superficial mold growth: occurs on wet coconuts.

- Keep storage conditions optimal (temperature, humidity).

## Corn



### HARVEST

**Quality:** High-quality sweet corn has uniform size and color (yellow, white or bicolor), sweet, plump, tender, well-developed kernels; fresh, tight, green husks, and is free from insect injury, mechanical damage, and decay.

**Harvest tips:**

- *Harvest early in the day, when still cool.*
- *Put directly into the cooler.*
- *Can be iced in the field.*
- *Can be field-packed.*
- *Handle like a tomato. Husks do not protect corn. Bruises will show up later if corn is tossed or squeezed.*
- *It is extremely important not to let corn heat up. Keep it in the shade.*
- *The faster corn is cooled, the better it will hold its sweetness.*

### HANDLING/PACKING

**Grades:** Feb. 12, 1992

- **U.S. Fancy:** Similar varietal characteristics and are well trimmed and well developed. Free from smut, worms, insect or worm injury, and decay. Free from injury caused by rust, discoloration, birds, worms, insects, disease, and mechanical or other means. Cobs must be fairly well filled with plump and milky kernels and fairly well covered with fresh husks. Cob must be at least 6". May not be clipped. Tolerance: 10% (2% for decay).
- **U.S. Fancy, Husked:** Same as U.S. Fancy, except for amount of covering, trimming, clipping, and length. Must be at least 5". Tolerance: 10% (2% for decay).
- **U.S. No. 1:** Similar varietal characteristics and are well trimmed and well developed. Free from smut, decay, rust, discoloration, and damage from birds, worms, insects, disease, and mechanical or other means. Cobs must be fairly well filled with plump and milky kernels and fairly well covered with fresh husks. Cob must be at least 5". Tolerance: 10% (2% for decay).
- **U.S. No. 1, Husked:** Meets U.S. No. 1 standards except for covering, trimming, clipping, and length of cob. Must be husked, properly trimmed, may be clipped (but well-clipped), and at least 4" long. Tolerance: 10% (2% for decay).
- **U.S. No. 2:** Similar varietal characteristics and are fairly well trimmed and fairly well developed. Free from smut and decay. Free from serious damage caused by birds, worms, insects, disease, mechanical, or other means. At least moderately filled with plump and milky kernels, and fairly well covered with fresh husks. May be clipped, but only properly. Tolerance: 10% (2% for decay).

**Cooling:** Maximum quality is retained by pre-cooling to 32°F (0°C) within 1 hr of harvest.

- Hydro-cooling (and top-iced after cooling)
- Package ice and top-ice if pre-cooling facilities are unavailable
- Injection of slush ice into cartons: as effective as hydro-cooling and more effective than vacuum cooling.

**Washing:** *Not necessary, but may be washed.*

**Carton sizes:** *48 ears in 1 1/9 bushel box, or wire-bound wooden crates.*

## Corn

Materials: Waxed fiberboard cartons and returnable plastic containers are less commonly used. Some corn is pre-packaged in PVC film-overwrapped trays.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-98%
- Respiration: 15-25 mL/kg hr at 32°F (0°C)
- Air composition: Avoid <2% O<sub>2</sub> or >15% CO<sub>2</sub>
- Ethylene producer: Trace. Very high concentrations of ethylene can yellow the husks.
- *Damage potential: High. Sensitive to overheating. Cool quickly.*
- Shelf life: 4-6 days

### PESTS/DISEASES

Decay: Decay is not usually a serious problem, but when present, it typically occurs on the husk and silks. Trimming ears can promote decay development on the cut kernels and other damaged tissues mainly caused by *Alternaria alternata* (Fr.) Keissler, *Fusarium moniliforme* Sheldon, and *Mucor hiemalis* Wehmer.

- Maintain proper sanitation.
- Maintain proper storage temperature.

## Cranberries



### HARVEST

Quality: Fruit red color intensity, glossiness, uniformity, and freedom from defects are the major quality characteristics for fresh and frozen cranberries. Maximum redness is desired, without letting the fruit become overmature.

### HANDLING/PACKING

Grades: Aug. 26, 1971

- **U.S. No. 1:** Of one variety or have similar varietal characteristics and are clean, mature, firm, and not soft or decayed. Free from damage caused by moisture, bruises, freezing, smothering, scarring, sunscald, foreign material, disease, insects, or mechanical or other means. Color: Individual cranberries shall be at least fairly well colored, and the cranberries in the container shall be fairly uniform in color. Tolerance: 5% (3% for soft or decayed berries [5% at destination] and 5% for uniform color).

Cooling: Forced-air cooling, if necessary.

Washing: Washing is not necessary for cranberries.

Carton sizes:

#### Weights:

- Cartons containing 24 12-oz. polybags
- 20-, 25-, and 30-lb. cartons
- Wood totes, for bulk sales

**Sizes:** Minimum diameter:  $1\frac{13}{32}$ "

### STORAGE

- Temperature: 35.6°F (2°C). Red color can be increased by storing at 44.6-50°F (7-10°C) for a few weeks after harvest.
- Humidity: 90-95%
- Respiration: 2 mL/kg hr at 32°F (0°C)
- Air composition: Not used
- Ethylene producer: Low
- Damage potential: Chilling-sensitive; chilling-injury can be reduced by warming to 69.8°F (21°C) for 1 day per month.
- Shelf life: 2-4 months

### PESTS/DISEASES

Various fungi: End rot, black rot, viscid rot, yellow rot, and Botryosphaeria fruit rot.

- Store at <1% O<sub>2</sub>.
- Store at 100% N<sub>2</sub>.

## Cucumbers



### HARVEST

Quality: Firm, glossy, crisp and dark green. Fruit is overripe when skin starts yellowing and seeds become hard.

Harvest tips:

- *Harvest when dry; doesn't matter if it's hot outside.*
- *Do not ice.*
- *Avoid pulling off stem-end of cucumber by twisting and snapping.*
- *Harvest every other day.*

### HANDLING/PACKING

Grades: Mar. 1, 1958

- **U.S. Fancy:** Well colored, well formed, not overgrown, and fresh, firm, and free from decay and sunscald. Shall be free from injury caused by scars and from damage caused by yellowing, sunburn, dirt or other foreign material, freezing, mosaic or other disease, insects, cuts, bruises, or mechanical or other means. Tolerance: 10% (1% for decay).
- **U.S. Extra No. 1:** Combination of U.S. Fancy and U.S. No. 1, where at least 50% must meet the criteria for U.S. Fancy.
- **U.S. No. 1:** Fairly well colored, fairly well formed, not overgrown, and fresh, firm, and free from decay and sunscald, and free from damage caused by scars, yellowing, sunburn, dirt, or other foreign materials, freezing, mosaic or other disease, insects, cuts, bruises, or mechanical or other means. Tolerance: 10% (1% for decay).
- **U.S. No. 1 Small:** Meets the requirements of U.S. No. 1 except for size.
- **U.S. No. 1 Large:** Meets the requirements of U.S. No. 1 except for size.
- **U.S. No. 2:** Moderately colored, not badly deformed, not overgrown, and fresh, firm, free from decay and free from damage caused by freezing, sunscald, cuts and from serious damage caused by scars, yellowing, sunburn, dirt or other foreign material, mosaic or other disease, insects, bruises, or mechanical or other means. Tolerance: 10% (1% for decay).
- **Unclassified**

Cooling: Forced-air cooling

Washing: Brush washer



# Cucumbers

Carton sizes:

**Weights:**

- 40-lb. in 1 <sup>1</sup>/<sub>9</sub> bushel cartons and crates
- 20-lb. in <sup>5</sup>/<sub>9</sub> bushel cartons
- 24-count cartons

**Diameter:**

- U.S. No. 1 Small: 1 <sup>1</sup>/<sub>2</sub>"-2"
- U.S. No. 1 Large: Minimum 2 <sup>1</sup>/<sub>4</sub>"
- All others: Maximum: 2 <sup>3</sup>/<sub>8</sub>"

**Length:**

- U.S. Fancy: Minimum 6"
- U.S. No. 1: Minimum 6"
- U.S. No. 1 Small: No requirements
- U.S. No. 1 Large: Minimum 6"
- U.S. No. 2: Minimum 5"

**STORAGE**

- Temperature: 50-54.5°F (10-12.5°C)
- Humidity: 95%
- Respiration: 12-15 mL/kg hr at 50°F (10°C)
- Air composition: Not particularly beneficial
- Ethylene producer: Low. Very sensitive to ethylene exposure
- Damage potential: Very chilling sensitive
- Shelf life: 14 days or less

**PESTS/DISEASES**

Many bacterial and fungal pathogens: *Alternaria* spp, black rot, Cottony leak, and soft rot.

- Avoid chilling-injury to reduce susceptibility.

## Dates



### HARVEST

Harvest maturity: Growth is usually divided in five stages of development known as hababouk, kimri, khalal, rutab, and tamr. Most dates are harvested in the tamr stage, when the fruit has about 60-80% sugar content depending on location and cultivar. These fruits can be harvested soft, semi-dry, or dry. Some varieties with low tannins but rich in sugar can be harvested at the khalal stage. For other varieties, dates harvested before full maturity must be ripened artificially. Very immature dates may not properly ripen artificially and consequently will be of poor quality.

Quality: Adequate size and color, small pit, thick flesh, free from dirt, sand and leaf particles, bird, insect and rodent damage, fungi and mold infestation and sugar crystal formation. The skin of dates should be smooth, with little or no shriveling, and golden-brown, amber, green or black in color depending on the variety. The texture may be soft and syrupy, or firm and dry, depending on the cultivar.

#### Harvest tips:

- May require postharvest ripening if picked early. Soft and semi-dry cultivars need to be dehydrated to eliminate excess moisture if not consumed immediately.
- Hydration is used to soften the texture of hard-type cultivars.

### HANDLING/PACKING

Grades: Aug. 26, 1955

- **U.S. Grade A or U.S. Fancy:** Whole or pitted dates of one variety that possess practically uniform color. For dates that are predominantly light amber in color, there may be not more than 5% that are dark amber in color, and for those dark amber in color, there may be not more than 5% that are light amber. Shall be practically uniform in size where not more than 10%, by weight, may be conspicuously larger or smaller than the approximate average size of the dates in the container. Shall be practically free from defects. For pitted dates there may be not more than one whole pit or two pit fragments for each 25-oz. of pitted dates. The limits shown in Chart I of the standard must also not be exceeded. Dates shall possess a good character where not less than 75%, by weight, are well developed, well fleshed, and soft, or at the time of packing are in a state of ripeness that within 15 days will develop into such character. The remainder may possess reasonably good character, including not more than a total of 2% possessing semi-dry calyx ends, and none may possess dry calyx ends. Dates may not score less than 90 points when scored in accordance with the scoring system outlined in the standard.
- **U.S. Grade B or U.S. Choice:** Whole or pitted dates (other than whole dry dates for processing) that are one variety and possess color reasonably uniform for the type. For dates that are predominantly light amber in color, there may be not more than 10% that are dark amber; and for those dark amber in color, there may not be more than 10% that are light amber. Dates shall be reasonably uniform in size where not more than 15%, by weight, of the whole or pitted dates may be conspicuously larger or smaller than the approximate average size of the dates in the container. Shall be reasonably free from defects. For pitted dates there may be not more than one whole pit or two pit fragments for each 25 oz. of pitted dates. The limits shown in Chart II of the standard must also not be exceeded. Dates shall possess reasonably good character. Dates shall be pliable with not less than 75% that are reasonably well developed and reasonably well fleshed, or at time of packing are in a state of ripeness that within 15 days will develop into such character. The remainder may possess fairly good character including not more than 10% possessing semi-dry calyx ends and dry calyx ends, provided, not more than 2% possess dry calyx ends. Dates may not score less than 80 points.

## Dates

- **U.S. Grade B (Dry) or U.S. Choice (Dry):** Whole dry dates for processing that are of one variety, possess reasonably good color, are reasonably uniform in size, are reasonably free from defects and possess a reasonably good character. Reasonably good character means that the dates may be firm and dry, that not less than 75%, by weight, are reasonably well developed and reasonably well fleshed and that the remainder are fairly well developed and fairly well fleshed. May not score less than 80 points.
- **U.S. Grade C or U.S. Standard:** Whole or pitted dates (other than whole dry dates for processing) that are of one variety or of date pieces or macerated dates that possess fairly good color. For whole or pitted dates that are predominantly light amber in color, there may be not more than 20% that are dark amber in color, and those dark amber in color, there may be not more than 20% that are light amber. For macerated or date pieces, the color may be variable throughout the mass, may be slightly dull but not off-color, and must be typical of properly prepared dates of these styles. Dates shall be fairly uniform in size except for date pieces or macerated dates. Not more than a total of 20%, by weight, of the whole or pitted dates may be conspicuously larger or smaller than the approximate average size of the dates in the container. Dates shall be fairly free from defects. For whole dates, the defects or defective units should not exceed the limits shown in Chart III of the standard. For pitted dates, fairly free from defects means not more than one whole pit or two pit fragments for each 25 oz. of pitted dates may be present. Also the limits shown in Chart III shall not be exceeded. For macerated or date pieces, not more than one whole pit or two pit fragments for each 25 oz. of pitted dates may be present and the mass shall consist of clean and sound date material, fairly free from defects that seriously affect the appearance, edibility, or keeping quality of the product. Dates shall be of fairly good character. May be firm but are pliable, may possess semi-dry calyx ends and not less than 80%, by weight, are fairly well developed and fairly well fleshed, or at time of packing are in a state of ripeness that within 15 days will develop into such character. The remainder may fail to possess such fairly good character or may possess dry calyx ends. For macerated or date pieces, the character may be variable throughout the mass but not seriously affected by dry calyx end material or inedible portions of dates. May not score less than 70 points.
- **U.S. Grade C (Dry) or U.S. Standard (Dry):** Whole dry dates for processing that are of one variety, that possess fairly good color, are fairly uniform in size, are fairly free from defects and possess a fairly good character. Dates may be firm and dry but are fairly well developed and fairly well fleshed. May not score less than 70 points.
- **Substandard:** Fail to meet the requirements of U.S. Grade C or U.S. Standard or U.S. Grade C (Dry) or U.S. Standard (Dry), whichever is applicable.

### Cooling:<sup>4</sup>

- Forced-air cooling is recommended
- Hydro-cooling can be used to cool khadal dates to near 32°F (0°C) in 10-20 min. but requires effective disinfection of water and removal of excess moisture before packing.

Washing:<sup>4</sup> May be washed in sanitized water. Can be cleaned with a damp cloth

Carton sizes: Some are marketed in 15-lb. (6.8kg) flats of fiberboard or wood, others in 5- or 10-lb. (2.3 or 4.5kg) cartons.

### **Sizes for U.S. Medjool dates:**

- Jumbo: <10 dates per lb. (0.45 kg)
- Mixed: 10-15 dates per lb.
- Conventional: >15 dates per lb.

## Dates

**Materials:** Large reinforced cartons are used for packing of dry dates, especially for export. Consumer packages are made in a number of sizes and shapes, including bags of transparent film or trays over wrapped with films. Round fiberboard cans with metal tops and bottoms containing 1.1-2.2 lb. (500-1000g) are also used as well as rigid transparent plastic containers with a capacity of 0.44-0.66 lb. (200-300g).

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 70-75%
- Respiration: Very low, < 5 mg CO<sub>2</sub> /kg hr at 68°F ( 20°C) at the khalal stage, and < 2 mg /kg hr at the rutab and tamr stages
- Air composition: No CA information given
- Ethylene producer: Low. Ripe dates are not sensitive to ethylene exposure.
- Damage potential: Ripe dates at rutab or tamr stages are not sensitive to chilling and freezing temperatures. Freezing temperatures can injure dates at early stages of kimri and khalal. Some varieties may develop sugar spots or crystals during storage.
- Shelf life: Partially dried dates: one year at 32°F (0°C). Fully mature soft and firm 'Deglet Noor' dates: more than one year when stored at 0°F (-17.5°C). Dry dates: many years at 68°F (20°C)

### PESTS/DISEASES

**Yeast:** Causes deterioration through fermentation.

**Various fungi:** Cause molding. May result in significant losses before or just after harvest during rainy or high RH periods and can attack fruits at the khalal or rutab stages. Most of these fungi will not grow on dried dates.

- Steam-hydrated dates are more resistant to attack by microorganisms than natural or nonhydrated dates.

**Bou Faroua disease:** Caused by certain species of mites. Affects dates at the hababouk stage. Larva develop around the fruit with a white filament netting, which causes fruits to drop prematurely.

***Coccotrypes dactyliperda*:** Also leads to fruit-drop at the immature green stage.

***Parlatoria blanchardii* scale:** Attacks fruit while they are still green.

**Date or carob moth:** Causes important postharvest losses on stored dates.

**Other insects:** *Batrachedra amydraula* Meyr, date stone beetle (*Coccotrypes dactyliperda* F.)

*Carpophilus hemipterius*, *Carpophilus multilatus*, *Urophorus humeralis*, and *Heptoncus luteolus* can cause serious damage for dates on the bunch or after harvest. Also, *Vespa orientalis*, *Cadra figulilella*, *Arenipes sabella*, and Mushroom mite (*Tyrophagus lintaeri* Osborn), which can infest stored dates.

- Use recommended temperatures and humidity levels to minimize impact.
- Fumigation by methyl bromide (for now) or phosphine, ionizing radiation, the use of low and/or high temperatures and MA treatments are registered to be used for insect control in dates.

## Eggplant



### HARVEST

Quality: Uniformly egg to globular shaped, has a fresh green calyx, firm flesh, and a dark purple skin. If eggplant is pithy or bitter it is overmature.

Harvest tips:

- *Harvest when dry.*
- *Can field-pack.*
- *Wear cotton gloves, and use to wipe field dust off.*
- *Harvest with clippers; keep stem short.*
- *Be careful not to scratch fruit with nails or stems.*

### HANDLING/PACKING

Grades: Oct. 29, 1953

- **U.S. Fancy:** Similar varietal characteristics, well colored, firm, clean, well shaped, and free from decay and worm holes and from injury caused by scars, freezing, disease, insects, or mechanical or other means. Tolerance: 10% (1% for decay).
- **U.S. No. 1:** Similar varietal characteristics, fairly well colored, firm, clean, fairly well shaped, and free from decay and worm holes and from damage caused by scars, freezing, disease, insects, or mechanical or other means. Tolerance: 10% (1% for decay).
- **U.S. No. 2:** Firm, free from decay and from serious damage caused by freezing, disease, insects, or mechanical or other means. Tolerance: 10% (1% for decay).
- **Unclassified**

Cooling: Rapid cooling to 50°F (10°C) immediately after harvest is necessary.

- Hydro-cooling
- Forced-air cooling
- Room cooling after washing (less effective)

Washing: Can be batch-washed or dipped in water to remove field dust.

Carton sizes:

**Weights:**

- 25-lb. In 1 <sup>1</sup>/<sub>9</sub> bushel cartons

**Sizes:**

Length; count (number of fruit/box)

- Small: 4.75-5.5"; 32
- Medium: 7.5-8.25"; 24
- Large: 8.25-9.5"; 18
- Extra Large: 9.5-10.25"; 16

# Eggplant

Materials: Cartons are generally waxed fiberboard or wire-bound crates. Fruit may be individually wrapped in paper.

## **STORAGE**

- Temperature: 50-53.6°F (10-12°C)
- Humidity: 90-95%
- Respiration: 32-41 mL/kg hr at 54.5°F (12.5°C)
- Air composition: Not beneficial
- Ethylene producer: 0.1-0.7  $\mu$ L/kg hr. Sensitive to ethylene exposure
- Damage potential: Chilling-injury
- Shelf life: 14 days or less

## **PESTS/DISEASES**

Various diseases: Black mold rot, gray mold rot, hairy rot, soft rot, and *Phomopsis* rot.

- Avoid chilling-injury.
- Avoid extended storage.

## Elderberries



### HARVEST

Harvest maturity: Harvest when fruit are sufficiently large and have changed to an acceptable purplish-black color. The fruit do not mature at the same time so several pickings are necessary over a 1-2 week period.

Quality: Fruit throughout each cluster should be firm, bright, with the proper cultivar-specific color and free of decay or mechanical or insect injury. For fresh market it is also important to have large and uniform fruit throughout the cluster. A long shelf life with retention of both firmness and flavor is also desirable for market.

### HANDLING/PACKING

Grades: Elderberries are not graded in the U.S.

Cooling: Quick-cooling after harvest to recommended storage temperature is desirable

- Forced-air

Washing: Not recommended

Carton sizes: Since fresh market volumes are not large, container sizes and packaging tend to be those used for similar, but more common berries, e.g., raspberries.

### STORAGE

- Temperature: 31.1-32°F (- 0.5-0°C)
- Humidity: 95%
- Respiration: No data available
- Air composition: No known information on the effect of CA on elderberries
- Ethylene producer: Low. Low sensitivity to ethylene
- Damage potential: Not chilling-sensitive
- Shelf life: 5-14 days

### PESTS/DISEASES

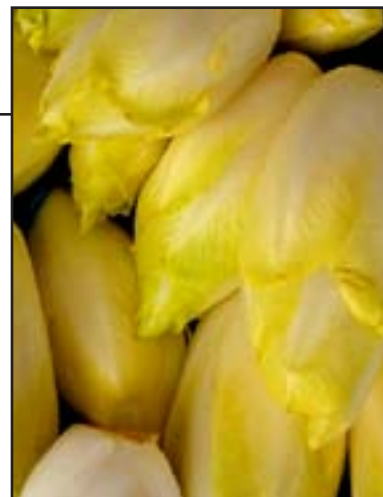
Postharvest decay: Can be minimized by avoiding picking wet or over-ripe fruit.

Unidentified mildew variety: Can be a problem on ripe fruit, especially if the weather is cool during ripening and there is poor air circulation around the plants.

Bird feeding on ripe fruit: Can be a serious pest problem.

- Promptly harvest ripe fruit.
- Take various bird repellent measures.

## Endive and Escarole



### HARVEST

Harvest season: Cool-weather crop.

Quality: Clean, free of browning, crisp and bright green. Young, tender leaves are preferred over tough, older leaves. Tough and overly bitter leaves are overmature.

Harvest tips:

- Harvest early or when cool. Wetness is okay.
- Use a field knife to harvest.
- Harvest into a container holding 24 heads.
- Damaged or yellow leaves should be removed.
- Cut above ground to keep knife clean and remove only the good portion – a good picker will not have to re-trim.
- Wipe field knife on pants between each cut.
- Be careful not to handle roughly; endive and escarole can be bruised.
- Cut open several heads to make sure there is no tip burn (brown on edges of internal leaves).

### HANDLING/PACKING

Grades: Oct. 1, 1964

- **U.S. No. 1:** Similar varietal characteristics and are fresh, well trimmed and fairly well blanched, free from decay and from damage caused by seedstems, broken, bruised, spotted, or discolored leaves, wilting, dirt, disease, insects, or other means. Tolerance: 10% (5% for serious damage, 2% for decay).
- **Unclassified**

Cooling:

- Hydro-cooling

Washing: Wash in water tank with sanitizer; drain upside down.

Carton sizes:

**Weights:**

- 30-40 lb. cartons or crates
- 1 1/9 bu. carton or crate

Materials: Cartons can be packed with ice.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-100%
- Respiration: 22.5 mL/kg hr at 32°F (0°C)
- Air composition: None recommended
- Ethylene producer: Very low. Sensitive to ethylene exposure
- Damage potential: *Sensitive to overheating*
- Shelf life: 2-3 weeks

### PESTS/DISEASES

Similar to those of leaf lettuces.



# Fennel



## HARVEST

Quality: Uniform and brilliant-white leafy sheathes that must be turgid and crispy, with no symptoms of cracking or darkening.

Harvest tips:

- *Harvest in the cool of the day.*
- *Don't let overheat.*
- *Harvest with a field knife.*

## HANDLING/PACKING

Grades: Fennel is not graded in the U.S.

Cooling: Hydro-cooling

Washing: Can be washed.

Materials: Plastic or cardboard boxes. *Should be top-iced to keep leafy top crisp.*

## STORAGE

- Temperature: 32°F (0°C)
- Humidity: 90-95%
- Respiration: 9-10 mL/kg hr at 32°F (0°C)
- Air composition: None has been reported.
- Ethylene producer: Low
- Damage potential: Low
- Shelf life: 2 weeks

## PESTS/DISEASES

Fennel is generally resistant to post-harvest pathogens.

## Figs



### HARVEST

Harvest maturity: Fresh market figs must be harvested when almost fully ripe and firm to be of good eating quality. Skin color and flesh firmness are dependable maturity and ripeness indices: Black Mission figs should be light to dark purple rather than black and should yield to slight pressure; Calimyrna figs should be yellowish-white to light yellow and firm. Figs for drying should fully ripen and partially dry on the tree before harvesting, with completion of drying to about 17% moisture, done using solar drying or a dehydrator at 140 °F (60 °C).

Quality: Skin color and flesh firmness are correlated to quality and postharvest life. Flavor is influenced by stage of ripeness and overripe figs can become undesirable due to fermentative products. Other quality indices include absence of defects (such as bird-peck, sunburn, scab, skin break and stem shrivel), insects and decay.

Harvest tips:

- Pickers should wear gloves as a protection against fig juice.
- Handling figs to avoid infection with *Aspergillus* species is very important to minimize formation of mycotoxins.
- Solar heating reduces insect infestations in ripening and drying figs.

### HANDLING/PACKING

Grades: Figs are not graded in the U.S.

Cooling: Expedited forced-air cooling to 32 °F (0 °C) is strongly recommended.

Washing: Not recommended.

Materials: Figs are hand-picked and packed in a one-layer box because fully mature fresh figs are soft, easily bruised, and highly perishable.

### STORAGE

- Temperature: 30-32°F (-1-0°C)
- Humidity: 90-95%
- Respiration: 2-4 mL/kg hr at 32°F (0°C)
- Air composition: 5-10% O<sub>2</sub> and 15-20% CO<sub>2</sub> is effective in decay control, firmness retention, and reduction of respiration and ethylene production.
- Ethylene producer: Low. Ethylene may stimulate softening and decay, especially if kept at 41°F (5°C) or higher.
- Damage potential: Not chilling-sensitive. Extended storage in controlled atmospheres can result in loss of characteristic flavor. Figs exposed to < 2% O<sub>2</sub> and/or > 25% CO<sub>2</sub> develop off-flavors due to fermentation.
- Shelf life: 1-2 weeks in air and 3-4 weeks in controlled atmosphere for California-grown Black Mission and Calimyrna figs.

## Figs

### PESTS/DISEASES

Alternaria rot (*Alternaria tenuis*): Appears as small, round, brown-to-black spots over the fruit surface. Any cracks on the skin make fruit more susceptible to this rot.

Black mold rot (*Aspergillus niger*): Appears as dark or yellowish spots in the flesh with no external symptoms. At advanced stages the skin and flesh turn slightly pink color and white mycelia with black spore masses follow.

Endosepsis (soft rot) (*Fusarium moniliformis*): Appears in the cavity of the fig, making the pulp soft, watery, and brown with sometimes an offensive odor.

Recommendations to reduce the above diseases include:

- Control orchard insects to reduce fruit damage and transmission of fungi.
- Enforce strict sanitation of picking and transporting containers.
- Carefully handle to minimize abrasions, cracks and other physical damage.
- Avoiding picking figs for fresh market from the ground.
- Enforce prompt cooling to 32°F (0°C) and maintain the cold chain through to the consumer.

Souring: A pre-harvest problem resulting from yeasts and bacteria carried into figs by insects, especially vinegar flies, resulting in odors of alcohol or acetic acid.

## Garlic



### HARVEST

**Quality:** Clean, white (or other color typical of the variety), and well-cured (dried neck and outer skins). The cloves should be firm to the touch.

**Harvest tips:**

- Loosen with a bed lifter or fork before harvesting.
- Roots should be left intact if dry, or they can be cut off with a field knife.

### HANDLING/PACKING

**Grades:** Sep. 4, 1944

- **U.S. No. 1:** Similar varietal characteristics, mature and well cured, compact, with cloves well filled and fairly plump, free from mold, decay, and shattered cloves, and from damage caused by dirt or staining, sunburn, sunscald, cuts, sprouts, tops, roots, disease, insects, or mechanical or other means. Each bulb shall be fairly well enclosed in its outer sheath. Tolerance: 10% (2% for decay).
- **Unclassified**

**Cooling:** Not necessary

**Curing:** Cure in bundles of 10-12 heads in a warm ventilated environment for 10 days. Can be hung to cure or laid on a screen.

**Cleaning:** After curing, remove outer 1-2 layers of skin. Stem-end should be cut with at least 1" remaining.

**Carton sizes:**

**Weights:** Packed loose

- 5-, 10-, 22-, 30-lb. cartons
- Smaller bags or trays for retail

**Sizes:** Minimum diameter: 1.5"

### STORAGE

- Temperature: 68-86°F for curing; 30-32°F (-1-0°C) for long-term storage.
- Humidity: 60-70%
- Respiration: 2-6 mL/kg hr at 32°F (0°C)
- Air composition: 5-15% CO<sub>2</sub> (15% may cause a yellowing on some close after 6 months)
- Ethylene producer: Low. Not sensitive to ethylene exposure.
- Damage potential: Low
- Shelf life: 1-2 months for curing; 9+ months for long-term storage

### PESTS/DISEASES

**Penicillium rots:** A common problem in stored garlic. Affected garlic bulbs may show little external evidence until decay is advanced. Affected bulbs are light in weight and individual cloves are soft, spongy and powdery dry. In an advanced stage of decay, the cloves break down in a green or gray powdery mass.

- Store in a low humidity environment.

## Ginger



### HARVEST

Harvest maturity: Mature ginger rhizomes are harvested when the plant tops begin to wilt and die. Rhizomes should be plump with a dry, bright yellow-brown skin color. The sheen is soon lost after harvesting and the skin darkens. The rhizome can also be harvested at a very early stage before fiber development has taken place for use in pickles and confectionery.

Quality: Skin color, plumpness of tuber pieces, sheen on skin and absence of vegetative sprouts, blemishes, soil and insect injury. Young ginger is bright yellow to brown and has a high sheen with greenish-yellow vegetative buds, but no sprouts.

### HANDLING/PACKING

Grades: Ginger is not graded in the U.S.

#### Cooling:

- Forced-air
- Room cooling

Washing:<sup>5</sup> Hand or brush wash immediately to get a pale color.

Carton sizes: Sold in full telescoping 30-lb. (13.6kg), 20-lb. (6.8kg) fiberboard cartons or 5-lb. (1.7kg) cartons with film bags.

### STORAGE

- Temperature: 54-57°F (12-14°C)
- Humidity: 85-90%
- Respiration: 3.1-3.8  $\mu\text{L}/\text{kg hr}$  at 72°F (22°C).
- Air composition: No published recommendations.
- Ethylene producer: Very low. Not sensitive to ethylene exposure.
- Damage potential: Superficial mold growth can occur if condensation occurs on rhizomes. Mature ginger is chilling-sensitive if held below 54°F (12°C). Symptoms include loss of skin color and pitting of the skin. In severe cases there is internal breakdown. Dehydration is the most common problem and shriveling becomes pronounced after the loss of about 10% of harvest weight.
- Shelf life: 60-90 days.

### PESTS/DISEASES

Fusarium rot: Symptoms include pale brown discoloration of the vascular strands that invades the rest of the rhizome causing it to become brown and dry.

Pythium rot: Rhizome becomes soft and watery.

- Fungicides are not permitted but reasonable control is obtained if rhizome is held at 54-57°F (12-14°C).

Saprophytes: May grow on cut ends and injured areas. They are not parasitic but give these areas an unsightly appearance.

## Ginseng



### HARVEST

Harvest maturity: Ginseng is usually harvested 3-5 years after transplanting 1-year-old seedlings.

Quality: Firm main root without defects. There should be a clearly defined head (rhizome), body (main root), and legs (lateral roots). The ginseng shall be clean, well-dried, and brittle (it should not bend), free from external and internal defects, mold, rust and decay.

Harvest tips:

- Careful handling is mandatory as it is easy to bruise the surface of main roots and break lateral roots. Damaged areas provide a route for entry of microorganisms.

### HANDLING/PACKING

Grades: Jan. 18, 2007

Grade value is determined based on size and category value as outlined below.

- **U.S. Premium:** Consists of ginseng with a graded value of 90 or more
- **U.S. Select:** Consists of ginseng with a graded value of 75 to 89
- **U.S. Medium:** Consists of ginseng with a graded value of 60 to 74

Sizes:

**Small (diameter):**  $\frac{3}{16}$  -  $\frac{3}{8}$ "

**Length:** Short:  $\frac{1}{4}$  -  $\frac{3}{4}$ " Value 60, Medium: Larger than  $\frac{3}{4}$  to  $1\frac{1}{4}$ " Value 32,

Long: Larger than  $1\frac{1}{4}$ " Value 17

**Medium (diameter):** Larger than  $\frac{3}{8}$ " -  $\frac{5}{8}$ "

**Length:** Short : Up to  $1\frac{3}{4}$ " Value 40, Medium: Larger than  $1\frac{3}{4}$ " to  $2\frac{1}{2}$ " Value 31,

Long: Larger than  $2\frac{1}{2}$ " Value 28

**Large (diameter):** Larger than  $\frac{5}{8}$ " -  $\frac{7}{8}$ "

**Length: Short:** Up to  $2\frac{1}{4}$ " Value 45, Medium: Larger than  $2\frac{1}{4}$ " to 3" Value 38,

Long: Larger than 3" Value 38

**Extra large (diameter):** Larger than  $\frac{7}{8}$ "

**Length: Short:** Up to  $2\frac{1}{4}$ " Value 60, Medium: Larger than  $2\frac{1}{4}$ " to  $2\frac{3}{4}$ " Value 52,

Long: Larger than  $2\frac{3}{4}$ " Value 42

**Fiber** (small roots less than  $\frac{1}{8}$ " in diameter)/prongs: Value 11

**Culls** (unusable portion)/Foreign material: Value 0

Grade Determination:

- **Whole Root Score.** Separate and/or break prongs and fiber from whole roots (i.e., the main root or upper portion of the main root which must also have a tapered top or crown), weigh, and record. Separate and weigh the culls and foreign material. Sort the balance of the sample into whole root size categories above and weigh each category. Determine the score for each category by dividing the category value by 450 (if grams) or 16 (if ounces) and multiply the result by the weight of the category. Add the scores for all the categories to determine the Whole Root Score.

## Ginseng

- **Deductions.** Weigh the external and internal defects (pathological and/or physiological defects consisting of cuts, external discoloration, internal green or red discoloration, insect, mold, scab or other means that affect the appearance or marketing quality) and determine each percentage. Divide the external defects percentage by 2 (i.e., 6% would be recorded as 3) to determine the external defects deduction. The internal defects percentage is equal to the internal defects deduction. Add the external and internal defects deductions to determine the Total Root Deductions.
- **Graded Value.** Subtract the Total Root Deductions from 100 and multiply the results by the Whole Root Score to determine the Graded Value, and hence the grade classification, i.e., U.S. Premium, Select, or Medium.

The origin of the ginseng, color, and/or wrinkle may be specified with the grade. External color ranges from “Light” to “Dark” as measured using Visual Aid GIN. CC-1. Wrinkle classifications include “Smooth,” “Slight Wrinkle,” and “Wrinkle” as measured using Visual Aid GIN. IDENT-1.

Cooling: Cool to below 41°F (5°C) to retard deterioration such as weight loss and decay.

- Hydro-cool
- Forced-air cool

Washing: Hand wash to minimize damage

Materials: Store in trays complete with packet pack and polyliners.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: >95%
- Respiration: 2.75 mL/kg hr at 32°F (0°C)
- Air composition: 1% O<sub>2</sub> and >5% CO<sub>2</sub> reduces microorganism growth and attenuated cavitation. Cavitation is significantly reduced at 15% CO<sub>2</sub>
- Ethylene producer: Very low. Not sensitive to ethylene exposure
- Damage potential: Not chilling-sensitive and should be stored as cold as possible without freezing.
- Shelf life: 2 months

### PEST/DISEASES

Gray mold (*Botrytis cinerea*): Lesions frequently begin in wounds and spread to other areas of the roots.

- Store at low temperatures and use optimum air composition.

# Gooseberries and Currants

## HARVEST

Quality: Fruit throughout each cluster should be firm, bright, with the proper cultivar-specific color, and be free of decay or mechanical or insect injury.

## HANDLING/PACKING

Grades: Gooseberries and currants are not graded in the U.S.

Cooling: Forced-air

Washing: Gooseberries and currants should not be washed.

Carton sizes:

### Weights:

- Trays holding 12 half-pint containers

Materials: Vented clamshell containers are standard.

## STORAGE

- Temperature: 31-32°F (-0.5-0°C)
- Humidity: 95%
- Respiration: 2.5-3.5 mL/kg hr at 32°F (0°C)
- Air composition: Gooseberry – 10-15% CO<sub>2</sub>, 1.5% O<sub>2</sub>; red currant – 18-20% CO<sub>2</sub>, 2% O<sub>2</sub>
- Ethylene producer: No data available
- Damage potential: Low
- Shelf life: 2 1/2 to 3 weeks

## PESTS/DISEASES

Gray mold rot

- Avoid storage at temperatures above 50°F (10°C).

American powdery mildew





## Grapefruit



### HARVEST

**Quality:** Shall have a turgid, smooth peel and be relatively blemish-free. The fruit should be elliptical and firm. An appropriate balance of SSC:TA within the edible portion should be achieved and bitterness should be at a minimum. Fruit must also achieve a minimum juice content in markets that emphasize processing.

**Harvest tips:**

- Degreening is necessary for marketing early-season fresh grapefruit in areas where night temperatures remain high and is achieved through ethylene exposure under controlled conditions.
- Coatings can be applied to reduce water loss from the peel.

### HANDLING/PACKING

**Grades** (California and Arizona): Dec. 27, 1999

- **U.S. Fancy:** Similar varietal characteristics, mature, well colored and well formed. Fruit shall have a smooth texture, be fairly thin skinned and be free from decay, unhealed broken skins, hard or dry skins, dryness or mushy condition. Should also be free from injury caused by bruises, sprayburn, fumigation, exanthema, scars, green spots, scale, sunburn, oil spots, skin breakdown, sprouting, dirt or other foreign materials, disease, insects or damage by mechanical or other means. Tolerance: Defects at shipping point: 10% for color, 10% for remaining requirements (5% for very serious damage and 1% for decay). Defects en route or at destination: 10% for color, 12% for remaining requirements (10% for fruit having permanent defects or 7% for defects causing very serious damage, including 5% for very serious damage by permanent defects and 3% for decay).
- **U.S. No. 1:** Same as U.S. Fancy but may be fairly well colored, fairly smooth and shall not be excessively thick skinned. Fruit shall be free of decay and damage (as per mechanisms outlined in U.S. Fancy grade above). Tolerances: As per U.S. Fancy grade.
- **U.S. No. 2:** Similar varietal characteristics, mature, slightly colored, fairly firm and fairly well formed. Shall not be decidedly rough and shall be free from decay and serious damage (as per mechanisms outlined in U.S. Fancy grade above). Tolerances: As per U.S. Fancy grade.
- **U.S. Combination grade:** Consists of a combination of U.S. No. 1 and U.S. No. 2 grapefruit: 40% shall meet the requirements of the U.S. No. 1 grade. Tolerances: Defects at shipping point: 10% meeting U.S. No. 2 color requirements. 10% for remaining U.S. No. 2 requirements (5% for very serious damage and 1% for decay). Defects en route or at destination: 10% meeting U.S. No. 2 color requirements, 12% for remaining U.S. No. 2 requirements (10% for permanent defects, 7% for defects causing very serious damage, 5% for very serious damage by permanent defects and 3% for decay). Note: No part of either tolerance shall reduce for the lot as a whole the 40% of U.S. No. 1 grapefruit required in the Combination grade. Individual samples may have not less than the 30% of U.S. No. 1 required provided the entire lot averages within the percentage specified.
- **U.S. No. 3:** Similar varietal characteristics, mature, slightly colored and may be slightly spongy, misshapen and rough but not seriously lumpy. Fruit shall be free from decay, unhealed broken skins, hard or dry skins and from very serious damage (as per mechanisms outlined in U.S. Fancy grade above). Tolerances: Defects at shipping point: 10% for color, 10% for remaining requirements (1% for decay). Defects en route or at destination: 10% for color, 12% for remaining requirements (10% for permanent defects and 3% for decay).

## Grapefruit

**Sizes:** Fruit shall be fairly uniform in size meaning that not more than 5% in any sample may be more than one standard size larger or smaller than the standard size for the count packed (Example: A standard-size 64-count grapefruit means that 64 grapefruit of that uniform size will fit tightly when packed into a carton). Tolerance: 5%.

Grades (Florida): Feb. 20, 1997

- **U.S. Fancy:** Fruit shall have not more than  $\frac{1}{10}$  of the surface affected by discoloration where rust mite or other means have caused russeting of a light shade of golden brown, shall be firm, mature, have similar varietal characteristics, smooth texture, and thin skin. Shall be well colored, well formed and free from ammoniation, buckskin, caked melanose, decay, scab, sprayburn, unhealed skin breaks and wormy fruit. Fruit shall be free from injury caused by bruises, green spots, oil spots, scale, scars, skin breakdown, and thorn scratches. Shall be free from damage caused by dirt or other foreign material, disease, dryness, or mushy condition, hail, insects, sprouting, sunburn and other means. Tolerances: Defects at shipping point: 10% for grade requirements (5% for defects causing very serious damage and 1% for decay or wormy fruit). Defects en route or at destination: 12% for grade requirements (10% for permanent defects or 7% for defects causing very serious damage, including 5% for very serious damage by permanent defects and 3% for decay or wormy fruit).
- **U.S. No. 1 Bright:** Same as for U.S. No. 1 except that fruit shall have not more than  $\frac{1}{5}$  of their surface affected by discoloration. Tolerances: (Defects): As per U.S. Fancy grade above. (Discoloration): 10%. No sample may have more than 20% of the fruit with excessive discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1:** Not more than  $\frac{1}{3}$  of the surface, in the aggregate, may be affected by discoloration. Fruit shall have a fairly smooth texture and fairly thin skin and shall be fairly well colored. Fruit shall be firm, mature, have similar varietal characteristics, be well formed and free from decay and damage (as per the mechanisms outlined in the U.S. Fancy grade above). Tolerances: (Defects): As per U.S. Fancy grade. (Discoloration): As per U.S. No. 1 Bright grade.
- **U.S. No. 1 Golden:** Same as for U.S. No. 1 except for tolerances. Tolerances: (Defects): As per U.S. Fancy grade. (Discoloration): Not more than 30% shall have in excess of  $\frac{1}{3}$  of their surface, in the aggregate, affected by discoloration, and no part of any tolerance shall be allowed to increase this percentage. No sample may have more than 40% of the fruit with excessive discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1 Bronze:** Same as for U.S. No. 1 except for tolerances. Tolerances: (Defects): As per U.S. Fancy grade. (Discoloration): At least 30% shall have in excess of  $\frac{1}{3}$  of the surface, in the aggregate, affected by discoloration, and no part of any tolerance shall be allowed to reduce this percentage. The predominant discoloration on each of these fruits shall be of the rust mite type. No sample may have less than 20% of the fruit with the required discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1 Russet:** Same as for U.S. No. 1 except for tolerances. Tolerances: (Defects): As per U.S. Fancy grade. (Discoloration): As per U.S. No. 1 Bronze grade and at least 30% shall have more than  $\frac{1}{3}$  of their surface, in the aggregate, affected by any type of discoloration.
- **U.S. No. 2 Bright:** Same as for U.S. No. 2 except that fruit shall have not more than  $\frac{1}{5}$  of its surface, in the aggregate, affected by discoloration. Tolerances: (Defects): As per U.S. Fancy grade. (Discoloration): As per U.S. No. 1 Bright grade.
- **U.S. No. 2:** Not more than  $\frac{1}{2}$  of the surface, in the aggregate, may be affected by discoloration. Fruit shall be fairly firm, mature, have similar varietal characteristics and be slightly colored. Shall be not more than slightly misshapen and not more than slightly rough in texture. Shall be free from decay, unhealed skin breaks and wormy fruit and be free from serious damage caused by various mechanisms as outlined in U.S. Fancy grade above. Tolerances: (Defects): As per U.S. Fancy grade. (Discoloration): As per U.S. No. 1 Bright grade.

## Grapefruit

- **U.S. No. 2 Russet:** Same as for U.S. No. 2 except for tolerances. Tolerance: (Defects): As per U.S. Fancy grade. (Discoloration): At least 10% shall have in excess of  $\frac{1}{2}$  of the surface, in the aggregate, affected by any type of discoloration, and no part of any tolerance shall be allowed to reduce this percentage, and the entire lot shall average within the percentage specified.
- **U.S. No. 3:** Mature, misshapen, poorly colored, can have a rough texture but not be seriously bumpy, with similar varietal characteristics and can be slightly spongy. Shall be free from decay, unhealed skin breaks and wormy fruit and be free from very serious damage caused by various mechanisms as outlined in the U.S. Fancy grade above. Tolerances: Defects at shipping point: 10% for grade requirements (1% for decay or wormy fruit). Defects en route or at destination: 12% (10% for permanent defects and 3% for decay or wormy fruit).  
**Size** (All grades): Not more than 10% percent may vary more than  $\frac{1}{2}$ " in diameter per sample. Not more than 10% of the samples in any lot may fail to meet the requirements of size.

Grades (Texas and States other than California, Arizona and Florida): Sept. 5, 2003

Tolerances (for all grades): Please refer to Table I within the standard for allowable defects at shipping point, and Table II for allowable defects en route or at destination. Note: No tolerance shall apply to wormy fruit.

- **U.S. Fancy:** Not more than  $\frac{1}{10}$  of the surface, in the aggregate, may be affected by discoloration. Fruit shall have similar varietal characteristics and a smooth texture, be firm, mature, well formed and be well colored. Shall be free from ammoniation, bruises, buckskin, unhealed cuts, skin breakdown, decay, growth cracks, scab, sprayburn and wormy fruit. Fruit shall not be injured by green spots, oil spots, scale, scars, thorn scratches or any other cause.
- **U.S. No. 1:** Same as U.S. Fancy but not more than  $\frac{1}{2}$  of the surface, in the aggregate, may be affected by discoloration and shall be fairly well colored. Shall be fairly smooth in texture, fairly well formed and be free from bruises, unhealed cuts, caked melanose, growth cracks, sprayburn, decay and wormy fruit and not be damaged by any other cause.
- **U.S. No. 1 Bright:** Same as for U.S. No. 1 except that no fruit may have more than  $\frac{1}{10}$  of surface, in the aggregate, affected by discoloration.
- **U.S. No. 1 Bronze:** Same as for U.S. No. 1 except that all fruit must show some discoloration. Not less than the number of fruits required in Tables I and II outlined in the standard shall have more than  $\frac{1}{2}$  of their surface, in the aggregate, affected by discoloration. The predominating discoloration on these fruits shall be of the rust mite type.
- **U.S. Combination:** Consists of a combination of U.S. No. 1 and U.S. No. 2 grapefruit, provided that the number of U.S. No. 2 fruits specified in Tables I and II of the standard are not exceeded.
- **U.S. No. 2:** Not more than  $\frac{2}{3}$  of the surface, in the aggregate, may be affected by discoloration. Shall be fairly firm, mature, have similar varietal characteristics and may be slightly colored. Fruit shall be not more than slightly misshapen, and shall be not more than slightly rough in texture. Shall be free from bruises, unhealed cuts, growth cracks, decay, wormy fruit, and not seriously damaged by any other cause.
- **U.S. No. 2 Russet:** Same as for U.S. No. 2 except that not less than the number of fruits required in Tables I and II of the standard shall have more than  $\frac{2}{3}$  of their surface, in the aggregate, affected by discoloration.
- **U.S. No. 3:** Mature, with similar varietal characteristics. May be misshapen, may be slightly spongy, may have rough texture but not be seriously lumpy or cracked, and may be poorly colored with not more than 25% of the surface being of a solid dark green color. Shall be free of unhealed cuts, decay, wormy fruit, and not very seriously damaged by any other cause.  
**Size** (All grades): Please refer to Table III in the standard which outlines grapefruit numbers and dimensions required for a standard  $\frac{7}{10}$  bushel carton.

## Grapefruit

**Cooling:**<sup>6</sup> Should be cooled immediately after harvest to below 50°F (10°C) with 95% RH to minimize postharvest pitting.

- Hydro-cooling
- Forced-air cooling
- Room cooling

**Washing:**<sup>6</sup> Brush wash with soap/detergent if necessary.

**Carton sizes:** Range from size 23 (23 fruit/carton) through to 56 (56 fruit/carton). Commonly packed, stored and shipped in  $\frac{4}{5}$  bushel cardboard cartons.

### STORAGE

- Temperature: 41-46.4°F (5-8°C) during transit and storage
- Humidity: 95%
- Respiration: < 10 mg CO<sub>2</sub>/ kg hr at 41-46.4°F
- Air composition: Very limited usage commercially, although some increased firmness and delayed senescence can be gained.
- Ethylene producer: Low. Ethylene exposure can be used for degreening.
- Damage potential: High shine water waxes will minimize chilling-injury and incorporated fungicides should control decay at these temperatures.
- Shelf life: 6 weeks

### PESTS/DISEASES

**Stem-end rots:** Develops unevenly at stem and styler ends, resulting in wavy margins. Mainly a problem in warm humid climates. *Diplodia natalensis* is prevalent in early-season fruit when temperatures are high and degreening is used. *Phomopsis citri* is favored during the winter months when temperatures are low and degreening is no longer necessary. *Alternaria citri*, which causes internal black discoloration, generally towards the stem, is less aggressive and is problematic in over-mature grapefruit and those in extended storage.

**Anthracnose:** A minor problem that can appear on late-season fruit.

**Brown rot:** *Phytophthora citrophthora* appears more frequently in mature fruit and fruit stored for longer durations at low temperatures.

**Green and blue mold:** *Penicillium digitatum* and *italicum* respectively, invade fruit through wounds made during harvest handling.

**Sour rot (*Geotrichum candidum*):** Immature fruit is resistant, but as fruit matures the disease can become a problem. Late-season grapefruit can become infected, especially since the disease develops more readily at temperatures above 59°F.

- Drenching harvested grapefruit with thiabendazole (TBZ) before packinghouse arrival is recommended for *Diplodia*, *Phomopsis*, *Anthracnose*, and *Penicillium* control. Application of aqueous imazalil or TBZ in the wax treatment also aids in control.
- Minimizing degreening time by delaying harvest will assist in controlling stem-end rot caused by *Diplodia* and *Anthracnose*.
- Careful harvesting and handling will reduce injuries.
- Good sanitation of packinghouse equipment and storage areas will help control diseases that lack effective chemical control, such as sour rot.
- Pre-cool or store fruit after packing to ≤50°F (10°C).

## Grapes



### HARVEST

Quality: Free of injury, decay, cracking, and sunscald, appear and feel turgid, have a dry stem scar, and are fully colored. The rachis should be green with berries firmly attached to pedicels. Bunches should be compact but with berries not too tightly packed.

### HANDLING/PACKING

Grades: Sep. 8, 1983

- **U.S. Fancy Table Grapes:** Of one variety (except when designated as assorted varieties) that are mature and well colored. The berries are firm, firmly attached to capstems, and are not split, shattered, crushed, dried, or wet, and are free from decay, mold, mildew, berry moth, russeting, and hail, and from damage caused by freezing, disease, insects, or other means. Tolerance: 10% (10% for size, 5% for serious damage, 2% for dried berries or berries affected by berry moth, and 1% for decay or mold).
- **U.S. No. 1 Table Grapes:** Of one variety (except when designated as assorted varieties) that are mature and fairly well colored. The berries are firm, firmly attached to capstems, and are not split, shattered, crushed, dried, or wet, and are free from decay, mold, and berry moth, and from damage caused by freezing, russeting, hail, mildew, other disease, insects, or other means. Tolerance: 10% (10% for size, 5% for serious damage, 2% for dried berries or berries affected by berry moth, and 2% for decay or mold).
- **U.S. No. 1 Juice Grapes:** Of one variety (except when designated as assorted varieties) that are mature and fairly well colored. The berries are firm, firmly attached to capstems, and are not split, shattered, crushed, dried, or wet, and are free from mold, decay and berry moth, and from serious damage caused by freezing, russeting, hail, mildew, other disease, insects, or other means. Tolerance: 15% (6% for serious damage, 2% for dried berries or berries affected by berry moth, and 3% for decay or mold).
- **Unclassified**

Cooling: Forced-air cooling to less than 35.6°F (2°C) within a day of harvest.

Washing: Grapes should not be washed.

Carton sizes:

**Weights:** No standard packaging

- Lugs
- Quart-sized ventilated plastic containers
- 2-lb. plastic slit bags

**Sizes:** Minimum diameter of  $\frac{9}{16}$ " for U.S. Fancy and U.S. No.1 Table Grapes.

# Grapes

## **STORAGE**

- Temperature: 31-32°F (-0.5-0°C)
- Humidity: 85-90%
- Respiration: 1.5 mL/kg hr at 32°F (0°C)
- Air composition: Not used
- Ethylene producer: Low. Gray mold growth can occur in the presence of ethylene.
- Damage potential: Low
- Shelf life: 4-7 weeks

## **PESTS/DISEASES**

### Gray mold

- Avoid exposure to ethylene.

### Black rot

- Make sure underdeveloped grapes aren't harvested.

Other diseases: Ripe rot, Macrophoma rot, powdery mildew, blue mold, Alternaria, Cladosporium rot.

## Greens – Cooking



### HARVEST

**Quality:** Leaves should be of similar varietal characteristics, fresh, fairly tender and clean, well trimmed, of characteristic color for the variety or type of greens, free from decay, discoloration, freezing injury, foreign material, disease, insects, and damage caused by coarse stalks or other mechanical means.

#### Harvest tips:

- *Harvest early in the day, keep cool and shaded.*
- *Snap leaves off the stalks, leaving long stalks on the leaves.*
- *Bunch in the field, at least 4" up the stalk, where leaves start to fill out.*
  - *5-7 leaves per bunch for green kale and collards*
  - *6-8 leaves per bunch for red kale*
  - *8-12 leaves per bunch for lacinato kale*
- *Don't pick newest leaves – these won't hold up in storage; conversely leaves that are too old are tough.*
- *Stem trimming may be required by some buyers.*
- *Bunches must be tied tightly to avoid slipping apart. Apply tie about 1/4 up from the bottom – usually about an inch into where the leaves begin. If it is too close to the bottom, bunches will fall apart*

### HANDLING/PACKING

Grades – Kale: Jul. 21, 2005

- **U.S. No. 1:** Kale of one type that are well-trimmed, not stunted, free from decay and from damage caused by yellow or discolored leaves, seedstems, wilting, bud burn, freezing, dirt, disease, insects, or mechanical or other means. Tolerance: 10% (1% for wet decay).
- **U.S. Commercial:** Same as U.S. No. 1, except for a tolerance for slightly yellowed or bronze edges to leaves, provided the edges are not dried.

Grades – Collards or Broccoli Greens: Apr. 16, 1953

- **U.S. No. 1:** Collard greens or broccoli greens, of similar varietal characteristics that are fresh, fairly tender, fairly clean, well-trimmed, and of characteristic color for the variety or type; which are free from decay and from damage caused by coarse stalks and seedstems, discoloration, freezing, foreign material, disease, insects, or mechanical or other means. Tolerance: 10% (5% for serious damage and 2% for decay).
- **Unclassified**

Grades – Mustard or Turnip Greens: Mar. 8, 1953

- **U.S. No. 1:** Mustard greens or turnip greens of similar varietal characteristics that are fresh, fairly tender, fairly clean, and which are free from decay and free from damage caused by seedstems, discoloration, freezing, foreign material, disease, insects, or mechanical or other means. Tolerance: 10% (5% for serious damage and 2% for decay).
- **Unclassified**

## **Greens – Cooking**

Cooling: Field heat should be removed as quickly as possible.

- Hydro-cooling
- Liquid icing
- Package icing (2.2-lb. of ice per 4-lb. of product)
- Top-icing

Washing: *Clean via hydro-cooling*

Carton sizes: 24 bunches packed in waxed leafy greens box or 1 <sup>3</sup>/<sub>4</sub> bu. carton. Alternate side-to-side four groups of six.

Materials: Collard, kale, turnip and mustard greens are typically bunched with a twist tie or rubber band – approximately 1-lb. per bunch. Waxed fiberboard cartons are commonly used.

### **STORAGE**

- Temperature: 32°F (0°C)
- Humidity: 95-98%
- Respiration: 9-11 mL/kg hr at 32°F (0°C)
- Air composition: 5-10% CO<sub>2</sub>, 7-10% O<sub>2</sub>
- Ethylene producer: Low. Very sensitive to ethylene exposure
- Damage potential: Sensitive to overheating
- Shelf life: 2 weeks (3 weeks for kale)

### **PESTS/DISEASES**

#### Bacterial soft rots

- Implement appropriate disease control during production.



## Guavas



### HARVEST

Harvest maturity: If eaten green, fruit should be harvested at the mature, firm stage without any signs of ripening. Fruit to be consumed soft and ripe are harvested when they show some sign of color change from green to yellow, as well as initial softening. SSC can vary from 3% in green fruit to >10% in ripe fruit, and the TA from 0.2-1.5%. Cultivars vary greatly in sweetness and acidity with potential seasonal variation in acidity.

Quality: Skin color is used to measure maturity and ripeness as are size and shape. Fruit should be free of defects, decay and insect damage. Some varieties have only a few seeds, while others have a large cavity full of seeds.

Harvest tips: Late harvesting, when fruit is riper, can lead to a high number of fruit fly stings and later, larvae in the flesh.

### HANDLING/PACKING

Grades: Guavas are not graded in the U.S.

Cooling:

- Room cooling
- Forced-air cooling
- Hydro-cooling

Carton sizes: Commonly shipped in 10-lb. (4.5kg) single-layer cartons with foam sleeves or wrapping to prevent injury.

Sizes:

- 3.5-4.7" (9-12cm)

Materials: MAP in polyethylene bags and use of wax coatings delays ripening/softening. Skin blackening is a problem when some wax coatings are applied.

### STORAGE

- Temperature: 46-50°F (8-10°C) for mature green, 41-46°F (5-8°C) for partially ripe fruit. Ripe, soft fruit can be held at 41°F (5°C).
- Humidity: 90-95%. Postharvest desiccation is a major problem leading to a dull yellow, sometimes wrinkled skin.
- Respiration: 4.2-31.6 mL/kg hr at 50°F (10°C)
- Air composition: 10% O<sub>2</sub> and 5% CO<sub>2</sub> for 24 hr before storage in air at 39°F (4°C) for 2 weeks delays color development and reduces chilling-injury.
- Ethylene producer: Low to moderate depending on variety and stage of ripeness. Ripening is accelerated by exposure to ethylene though immature fruit do not ripen properly and develop a "gummy" texture.
- Damage potential: Skin scald, pitting, and a failure to ripen if mature green or partially ripe when chilled. Browning of the flesh can occur, especially when injured. Decay incidence and severity increases with chilling-injury.
- Shelf life: 2-3 weeks for mature green and partially ripe fruit. 1 week for ripe, soft fruit.

### PESTS/DISEASES

Anthracose: latent infection.

Aspergillus rot, Mucor rot, Phomopsis rot and Rhizopus rot: Associated with insect stings or mechanical damage.

- Practice good orchard sanitation.
- Practice effective postharvest management, such as avoiding mechanical injury.
- Cool promptly.

## Honey Dew and Honey Ball Melons

### HARVEST

Harvest maturity: Non-hybrid honey dew melons are ready for harvest when the rind is slightly waxy and the color is mostly whitish with a light-green tinge. Fruit should be well filled out and covered by a fine fuzz of hairs. Hybrid Honey Dew melons will abscise (slip) when mature and are mostly creamy-white, slightly waxy, and may have very sparse netting. The blossom-end gives when pressed with the thumb and melons have a pleasant aroma. Less ripe and cold melons have little aroma. Casaba melons are ready to eat when the very furrowed or wrinkled peel is yellow and the blossom-end is springy. The flesh should be soft, almost white with a slight salmon cast around the seed cavity and be subtly sweet. No aroma is produced except for a hint of cucumber. Crenshaw melons are ready to eat when half the dark-green peel turns yellow, the blossom-end is springy and a pleasant spicy aroma is emitted at room temperature. The very sweet and juicy flesh should be salmon-color and soft. Entirely yellow and soft fruit are overripe and unpleasant to eat. Canary melons are ready to eat when the peel, generally smooth but sometimes furrowed, is bright canary-yellow (the brighter the peel, the riper the melon) and the oval shaped fruit is springy at the blossom-end. The flesh should be crisp, flavorful and white with a hint of pink around the seed cavity. A fragrant aroma is emitted at room temperature.



Quality: For honey dew melons: good internal quality of 8% SSC (10% in California). Superior honey dew melon quality is associated with a whitish peel, high SSC and round fruit shape. Full-slip hybrid honey dew melons, versus honey dew melons cut at harvest, are perceived by consumers to have superior flavor, texture and sweetness.

### Harvest tips:

- Honey dew melons should never be dropped more than 2-ft. (60cm), and all harvesting and packing line equipment should be well padded to reduce injury.
- Use of stackable, ventilated plastic field boxes 48"x48"x26" deep (1.2m x 1.2m x 0.6m) loaded onto a flatbed truck will greatly reduce crushing and bruising of fruits.
- Product quality and shelf life of full-slip, hybrid honey dew melons can be extended by applying an amino acid-chelated Ca (80 mM) rinse or soak prior to sizing/storage.

### HANDLING/PACKING

Honey dew fruit have no federal marketing standard for SSC except for May 1 through June 20, when all honey dew melons, regardless of grade, must be at 8% minimum.

### Grades: Apr. 1, 1967

- **U.S. No. 1:** Consists of honey dew or honey ball-type melons that are mature, firm, well formed, free from decay and from damage caused by dirt, aphid stain, rust spots, bruises, cracks, broken skin, sunscald, sunburn, hail, moisture, insects, disease, or other means. Tolerance: 10% (5% for defects and 1% for decay).
- **U.S. Commercial:** Meets the requirements of U.S. No. 1 grade except for the increased tolerances for defects. Tolerance: 20% (5% for defects and 1% for decay).
- **U.S. No. 2:** Consists of honey dew or honey ball-type melons which are mature, firm, fairly well formed, free from decay and from serious damage by any cause. Tolerance: 10% (1% for decay).
- **Unclassified**

## Honey Dew and Honey Ball Melons

**Cooling:** Honey dew melons cut from the vine need not be pre-cooled. Full-slip melons should be pre-cooled to 50-60°F (10-15°C) soon after harvest.

- Hydro-cooling
- Forced-air cooling

**Washing:** Wash through hydro-cooling if necessary.

**Carton sizes:** The number of fruit (based on a uniform fruit diameter and weight) per box to achieve a standard weight of 30-lb. (13.6kg). Size classes are: 4s, 5s, 6s, 8s and 9s.

### STORAGE

- Temperature: 50°F (10°C), 45°F (7°C) for ethylene ripened honey dew melons and full-slip honey dew melons
- Humidity: 90-95%, 95% for ethylene-ripened honey dew melons and full-slip honey dew melons
- Respiration: 4.1 mL/kg hr at 41°F (5°C)
- Air composition: Limited commercial use
- Ethylene producer: Very low. There is benefit, at time of shipping, from exposure to 100 µL/L ethylene at 55-77°F (12.5-25°C) for up to 24 hr. Full-slip honey dew melons should not be gassed with ethylene.
- Damage potential: Chilling-injury can occur at <45 °F with riper melons being less susceptible. Symptoms include patchy, long surface lesions, pitting and darkening.
- Shelf life: 3 weeks. Ethylene-ripened honey dew melons can be held for 7-10 days

### PESTS/DISEASES

**Bacterial brown spot:** Caused by *Pantoea ananatis*-formerly called *Erwinia anana*.

***Alternaria alternata* and *Cladosporium cucumerinum* rots:** Can be found on honey dew melons as a result of chilling-injury, cuts, punctures or holding fruit for too long in storage.

## Horseradish



### HARVEST

**Quality:** Uniformity of shape and size, firmness, smoothness, internal color of the roots, and freedom from hollow heart. Long and uniform roots with white color of fleshy rhizomes and pungent flavor are the most important quality criteria. Horseradish is ready to harvest after the leaves have been killed by frost. Sometimes it is harvested at an early stage of development and the roots are used for processing. Horseradish that is harvested when roots are actively growing does not store as well as roots that are conditioned by cold before harvest.

**Harvest tips:**

- *Dig with a fork or bed lifter.*
- *Cut all green off, but don't cut into the crown.*

### HANDLING/PACKING

**Grades:** Jul. 27, 1936

- **U.S. Fancy:** Firm, well trimmed, well shaped, fairly smooth, free from decay and hollow heart, and free from damage caused by dirt, sunburn, cuts, cracks, internal discoloration, mold, freezing, insects, mechanical or other means. Each root shall have good head formation. Tolerance: 10% (5% for hollow roots and 2% for decay).
- **U.S. No. 1:** Firm, well trimmed, fairly well shaped, not excessively rough, and are free from decay and hollow heart and from damage caused by dirt, sunburn, cuts, cracks, internal discoloration, mold, freezing, insects, mechanical, or other means. Each root shall have fairly good head formation. Tolerance: 10% (5% for hollow roots and 2% for decay).
- **U.S. No. 2:** Firm, well trimmed, free from decay and hollow heart, and free from serious damage caused by dirt, sunburn, cuts, cracks, internal discoloration, mold, freezing, insects, mechanical or other means. Tolerance: 10% (5% for hollow roots and 2% for decay).
- **Unclassified**

**Cooling:** Roots should be pre-cooled immediately after harvest to 39-41°F (4-5°C), or placed in storage at the recommended temperature and humidity.

- Forced-air cooling

**Washing:** Barrel-washer or pressure washer. *Wash after storage.*

# Horseradish

Carton sizes:

**Weights:**

- 44-55 lb. (20-25kg) sacks
- 2.2 lb. (1kg) packages
- For storage: 33lb. (15kg) polyethylene-lined crates
- For storage: 660-1,100lb. ( 300-500kg) containers

**Sizes:**

- U.S. Fancy: 1.5"+ diameter and 8"+ length
  - Diameter may be  $\frac{1}{16}$ " less for each half inch over 8" in length; but diameter may not be less than 1- $\frac{1}{4}$ "
- U.S. No. 1: 1- $\frac{1}{4}$ " + diameter and 6"+ length
  - Diameter may be  $\frac{1}{16}$ " less for each half inch over 6" in length; but diameter may not be less than 1"
- U.S. No. 2: Minimum 4" length and 1" diameter.

Materials: For long term storage, use plastic-lined bins or crates.

## STORAGE

- Temperature: 32°F (0°C)
- Humidity: 98-100%
- Respiration: 4mL/kg hr at 32°F (0°C)
- Air composition: Little benefit from controlled atmosphere
- Ethylene producer: Very low. Not sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 8-12 months

## PESTS/DISEASES

Verticillium dahliae: Results in discoloration of the vascular tissue, which is the major reason for loss of market quality.

## Jerusalem Artichokes



### HARVEST

Harvest maturity: Tubers are harvested in the late fall, generally after the first frost, but can also be harvested in winter in locations where freezing of the soil surface is uncommon.

Quality: Tuber size and shape are critical quality attributes and are strongly determined by cultivar and production conditions. Irregular tuber surface topography due to branching is undesirable.

Harvest tips:<sup>7</sup>

- Hand rakes can be useful in locating the tubers.

### HANDLING/PACKING

Grades: Jerusalem artichokes are not graded in the U.S.

Cooling: Cooling as soon as possible after harvest is recommended.

- Refrigerated storage
- Root cellars
- In situ field storage (only in locations where cold soil temperatures prevail throughout the winter, but soil surface does not normally freeze)

Washing: Dry brush or wash after storage and partially dry for market

Carton sizes: Polyethylene bags are the typical packaging material. Package physical parameters vary with storage temperature, product volume, and other factors.

Sizes: Larger tubers with smooth surfaces are preferred.

### STORAGE

- Temperature: 32-34°F (0-2°C)
- Humidity: 90-95%. Tubers shrivel readily at low RH and become more susceptible to decay.
- Respiration: 5.1 mL/kg hr at 32°F (0°C)
- Rate of dry matter loss: 0.162 g/kg day at 32°F (0°C)
- Air composition: Not adequately assessed
- Ethylene producer: Tubers are not sensitive to ethylene.
- Damage potential: Freezing at 14°F (-10°C), whether in the field or storage, causes rapid deterioration, but nonlethal freezing at 23°F (-5°C) causes little damage. Temperature at which freezing damage occurs and extent of damage varies with cultivar, season, preconditioning, rate of freezing, and other factors.
- Shelf life: 6-12 months

### PESTS/DISEASES

Various storage rots: Approximately 20 organisms causing storage rots have been isolated but the most frequent and serious are: *Botrytis cinerea Pers.*, *Rhizopus stolonifer*, *R. stolonifer* and *Sclerotinia sclerotiorum*. *Sclerotium rolfsii Sacc.* and *Erwinia carotovora ssp. carotovora* are not significant pathogens at temperatures below 68°F (20°C).

- Store at recommended temperature and humidity.
- Remove diseased tubers and minimize mechanical damage.

## Jicama



### HARVEST

Harvest maturity: Jicama roots only form with warm, short days and can be harvested at various stages of development. Young tender roots harvested from green plants (3.5-5.3 oz., 100-150g) are found in specialty markets. Fully mature roots weigh from 0.55-3.3 lb.

(250-1,500g) and are characterized by size and a well-developed periderm as well as by their starchy-sweet flavor.

Quality: Smooth and firm, with uniform shape and size, free from mechanical damage, and have a crisp, succulent, white sweet-starchy flesh.

Harvest tips:

- To harden the periderm, plant tops are removed mechanically or irrigation is stopped.
- The periderm is easily damaged when handling, which negatively affects appearance and increases rates of water loss and decay.

### HANDLING/PACKING

Grades: Jicama are not formally graded in the U.S. However, two grades are recognized in Hawaii based on size and freedom from defects including dirt, discoloration, growth cracks, roughness, insect damage, and mechanical injury.

Cooling: Jicama roots that are to be kept in storage or which require wound healing should be cured by holding at 68-77°F with 95-100% RH for >1 week.

Washing: Dry brush or wash after storage and partially dry for market.

Carton sizes: Typically packed in wooden crates of 20+ lbs. (9+kg) or in carton boxes of about 10-lb. (4.5kg) for export

### STORAGE

- Temperature: 54-59°F (12.5-15°C)
- Humidity: 80-90%
- Respiration: 2-4 mL/kg hr at 32°F (0°C) for intact roots and fresh cut pieces
- Air composition: No information available for intact roots. Decay development and discoloration of fresh-cut pieces was reduced by 5-10% in CO<sub>2</sub> atmospheres.
- Ethylene producer: Low. Not sensitive to ethylene exposure
- Damage potential: May develop symptoms of chilling-injury (external decay, internal discoloration and loss of crisp texture) after 1-3 weeks at 50°F (1°C)
- Curing: Wound curing can be achieved by holding roots at 68-77°F (20-25°C) with 95-100% RH for at least a week.
- Shelf life: 2-4 months. Leaf and stem sprouts may develop after 2 months with loss of weight and juiciness of the pulp.

### PESTS/DISEASES

Various decay organisms: *Penicillium*, *Rhizopus* and *Cladosporium* species can be found externally on roots.

- Minimize mechanical damage to the periderm during harvest .
- Avoid chilling-injury.

## Kiwifruit



### HARVEST

Harvest maturity: Kiwifruit produced in California require a minimum of 6.5% SSC and flesh firmness of 14-lb. (6.3kg) force. Fruit marketed locally with a minimum of handling may be held on the vine until the SSC reaches 10-12%.

Quality: At table ripeness, fruit should have at least 14% SSC with flesh firmness of 2-3 lb (0.9-1.35 kg) force, which is the penetration force measured with a  $\frac{5}{16}$ " (8 mm) tip.

Harvest tips:

- Curing occurs during the delay between harvest and cooling and is characterized by some water loss from fruit and a drying of the stem scar.

### HANDLING/PACKING

Grades: Oct. 15, 1986

- **U.S. Fancy:** Similar varietal characteristics, mature, carefully packed, clean well-formed, and not soft, overripe or shriveled. Shall be free from worm holes, broken skins that are not healed, sunscald, freezing injury, internal breakdown, and decay. Shall be free from damage caused by bruises, leaf. or limbrub, discoloration, hail, growth cracks, scab, scars, heat, sprayburn, sunburn, scale, insects, other diseases, and by mechanical or other means. Tolerance: Defects at shipping point: 8% (4% defects causing serious damage and 1% for internal breakdown or decay). Defects en route or at destination: 12% (8% permanent defects, 6% for defects causing serious damage, 4% for serious damage by permanent defects, and 2% for internal breakdown or decay).
- **U.S. No. 1:** Same as for U.S. Fancy grade except that fruit may be fairly well formed. Tolerances: Same as for U.S. Fancy grade.
- **U.S. No. 2:** Same as for U.S. Fancy grade except that fruit may be fairly clean and not badly misshapen. Tolerance: Defects at shipping point: 8% (4% for sunscald, insects, internal breakdown or decay and 1% internal breakdown or decay). Defects en route or at destination: 12% (8% for permanent defects, including 4% for sunscald or insects and 2% for internal breakdown or decay).

Carton sizes: Any size carton or configuration may be used in the U.S. as long as it is appropriately labeled. Tray-packed fruit may be placed in cartons of wood or fiberboard that contain one, two, or three trays. Appropriate padding should be placed between trays. Volume-filled (typically 23-lb.;10.4kg) or count-filled cartons are also available. Bagged fruit are generally placed in master cartons, commonly containing twenty 1-lb. (0.45kg) bags.

**Weights:**

- Actual fruit size is based on weight and is defined as the number of uniformly sized fruit required to constitute an 8-lb. sample.

**Sizes:**

- Size designations are based on number of fruit that can be placed on a single tray.

Cooling: Forced-air cooling

Washing: Dry brush after storage.



# Kiwifruit

## STORAGE

- Temperature: 32°F (0°C)
- Humidity: 90-95%
- Respiration: 1.5 mL/kg hr at 32°F (0°C)
- Air composition: 1-2% O<sub>2</sub> and 3-5% CO<sub>2</sub> at 32°F. Less than 1% O<sub>2</sub> may induce off-flavors and >7% CO<sub>2</sub> can cause internal breakdown of the flesh.
- Ethylene producer: Low at harvest maturity. Extremely sensitive to the presence of ethylene in storage.
- Damage potential: Hayward variety are chilling-sensitive near 32°F (0°C). Symptoms include granular, water-soaked tissue at the styler end of the fruit, diffuse pitting and a dark, scald-like appearance on the skin. Curing alleviates symptoms of chilling-injury.
- Shelf life: 4-5 months

## PESTS/DISEASES

Gray mold decay: May infect the fruit through senescent flower parts or through wounds.

Blue mold and phomopsis: Lesser commercial impact than gray mold.

- Use a fungicide application program.
- Manage harvest practices to reduce wounding.
- Harvest at the appropriate maturity.
- Practice good temperature management in the storeroom.
- Use controlled atmospheres.

Fungal infection: Mainly causes pitting when fruit has been stored for several months

## Kohlrabi



### HARVEST

Quality: Only young kohlrabi should be harvested, since mature product becomes woody and tough. Leaf stems are a good indicator of quality; they should be succulent and tender.

Harvest tips:

- *Pull off unsightly leaves and bunch with a twist-tie in the field.*

### HANDLING/PACKING

Grades: Kohlrabi is not graded in the U.S.

Cooling:

- Hydro-cooling
- Package icing
- Forced-air cooling

Washing: *Pressure wash roots if necessary.*

Carton sizes:

**Weights:**

- 1- $\frac{1}{9}$  bu. box – 24 bunches
- With tops: bunched like beets, with 3-5 kohlrabi per bunch

**Sizes:**

- 2-2  $\frac{1}{2}$ " for early to mid-season kohlrabi
- 4-5" for fall-grown kohlrabi

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 98-100%
- Respiration: 5 mL/kg hr at 32°F (0°C)
- Air composition: No benefit to controlled atmosphere
- Ethylene producer: Very low. Low sensitivity to ethylene
- Damage potential: Low
- Shelf life: 2-4 weeks with tops; 2-3 months without tops

### PESTS/DISEASES

Bacterial soft rot

Black rot

## Leeks



### HARVEST

Quality: Good-quality leeks are firm and smooth, free of blemishes, and have characteristic white stems with dark-green leaves. The cut bottoms should be flat; rounded bottoms may indicate prolonged storage. Should be trimmed so that only 12" of the green top remains.

Harvest tips:

- Use a fork or bed lifter to loosen.
- Cut roots short with scissors or a field knife.
- Cut tops in a V with scissors or a field knife – make sure they're the right size to fit in containers.

### HANDLING/PACKING

Grades: Leeks are not graded in the U.S.

Cooling:

- Hydro-cooling
- Crushed ice

Washing: Washing/peeling tunnel. *Pressure-wash the roots to remove dirt.*

Carton sizes:

**Weights:**

- 10-lb. 1/3 bu. cartons or wire-bound crates
- 12-count leafy greens carton

**Sizes:** At least 1" in diameter

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-100%
- Respiration: 5-10 mL/kg hr at 32°F (0°C)
- Air composition: 2-5% CO<sub>2</sub>, 1-3% O<sub>2</sub>
- Ethylene producer: Very low. Moderately sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 2-3 months (with ice)

### PESTS/DISEASES

Similar to pests and diseases that afflict onions in storage.

## Lemons



### HARVEST

Harvest maturity: The generally accepted standard is a minimum juice content of 28-30% by volume.

Quality: Intensity and uniformity of yellow color, size, shape, smoothness, firmness, freedom from decay and defects. Ripe lemons should have a pleasant citrus fragrance.

Harvest tips:

- Yellow lemons harvested when dark green have a much longer postharvest life than those picked yellow.
- Oil spotting, a rind blemish, can be minimized by avoiding harvesting of lemons when they are turgid and by careful handling to reduce physical stress.

### HANDLING/PACKING

Grades: Dec. 27, 1999

- **U.S. No. 1:** Mature, firm, fairly well formed, having the normal characteristic lemon shape and not materially flattened on one side. Fruit shall be fairly smooth (coarse pebbling is an indication of good keeping quality), be free from decay and areas that indicate contact with decay or mold (contact spot), internal evidence of *Alternaria* development, unhealed broken skins, hard or dry skins, exanthema, growth cracks, internal decline, red blotch, membranous stain, or other internal discoloration. Shall be free from damage caused by bruises, dry or mushy condition, scars, oil spots, scale, sunburn, hollow core, peteca, scab, skin breakdown, melanose, dirt, or other foreign material, other disease, insects, or other means. Shall be fairly well colored with the area of yellow color exceeding green. Tolerance: Defects at shipping point: 10% for color, 10% for remaining requirements (5% for defects and 1% for decay). Defects en route or at destination: 10% for color, 12% for remaining requirements (10% for permanent defects or 7 % for defects causing serious damage, including 5% for serious damage by permanent defects and 3% for decay).
- **U.S. Export No. 1:** Mature, firm, fairly well formed, fairly smooth, and free from decay, contact spot, internal evidence of *Alternaria* development, unhealed broken skins, exanthema, growth cracks, internal discoloration, and free from damage caused by bruises and dryness or mushy condition. At least 50% shall be free from damage caused by scars, oil spots, scale, sunburn, peteca, scab, skin breakdown, melanose, dirt or other foreign material, other disease, insects or other means and the remainder shall be free from serious damage by any cause. Lemons shall be moderately well colored with the area of greenish-yellow or yellow color exceeding the area of green. Tolerances: Defects: 10% (1% for decay, 3% for contact spot, 3% for broken skins that are not healed, 3% for growth cracks, 3% for internal evidence of *Alternaria* development, 3 % for internal discoloration, 5% for soft and 5% for damage by dryness or mushy condition). Color: 10%. Other: Samples may have not more than 10% points less than the percentage specified to meet the U.S. Export No. 1 requirements, provided no sample has more than double the percentage specified for any one of the defects outlined above.
- **U.S. Combination:** A combination of U.S. No. 1 and U.S. No. 2 lemons. At least 40% in each lot shall meet the requirements of U.S. No. 1 grade. Lemons shall be fairly well colored. Tolerance: Defects at shipping point: 10% for U.S. No. 2 color, 10% for remaining U.S. No. 2 requirements (5% for decay, contact spot, internal evidence of *Alternaria* development and internal decline [endoxerosis], and 1% for decay). Defects en route or at destination: 10% for U.S. No. 2 grade color, 12% for remaining U.S. No. 2 grade requirements, (10% for permanent defects, 7% for decay, contact spot, internal evidence of *Alternaria* development and internal decline and 3%

## Lemons

for decay). Defects at shipping point and en route or at destination: No part of any tolerance shall reduce for the lot as a whole, the 40% of U.S. No. 1 lemons grade required for the grade. Individual samples may not have less than 30% of the U.S. No. 1 lemons required, provided the entire lot averages within the percentage required.

- **U.S. No. 2:** Same as for U.S. No. 1 except that they may be fairly firm, reasonably well-formed, and reasonably smooth. Shall be free from serious damage caused by damage mechanisms outlined as per U.S. No. 1 grade above. Tolerance: Defects at shipping point: 10% for color, 10% for remaining requirements (5% for decay, contact spot, internal evidence of *Alternaria* development and internal decline [endoxerosis] and 1% for decay). Defects en route or at destination: 10% for color, 12% for remaining requirements (10% for permanent defects, 7% for decay, contact spot, internal evidence of *Alternaria* development and internal decline and 3% for decay).

**Carton sizes:** Common packaging specifications are 40-lb. (18.2kg) cartons, 10-lb. (4.6kg) mini-pack cartons, 8-lb. (3.6kg) consumer cartons, as well as 2, 3, and 5-lb. (0.9, 1.4 and 2.3kg) bags. Sizes include 75, 95, 115, 140, 165, 200 and 235 count. For the “standard pack”, boxes or cartons shall be tightly packed and well filled but not show excessive or unnecessary bruising because of overfilling. When packed in cartons, each container shall be at least level full at time of packing. For lemons packed for 165 carton count or smaller size, or equivalent sizes when packed in other containers, not less than 90% shall be within a diameter range of  $\frac{1}{4}$ ". When packed for sizes larger than 165 carton count, or equivalent sizes packed in other containers, not less than 90% of the lemons in any container shall be within a diameter range of  $\frac{3}{8}$ ". Tolerance: 5% for samples in any lot that fail to meet the requirements for the standard pack, standard sizing and fill.

**Cooling:** Most packing houses do not pre-cool lemons.

**Washing:**<sup>8</sup> Brush wash with soap/detergent if necessary.

### STORAGE

- Temperature: 45-54°F (7-12°C) depending on the maturity-ripeness stage at harvest, storage time and harvest season and area.
- Humidity: 85-95%
- Respiration: 5.3-6.3 mL/kg hr at 50°F (10°C)
- Air composition: 7.5-10% O<sub>2</sub> and up to 10% CO<sub>2</sub> can delay senescence, including loss of green color, but the risk of injury to fruit is high and is only rarely used.
- Ethylene producer: Low. Sensitive to ethylene exposure. Ethylene can be used for degreening but this may accelerate deterioration and decay.
- Damage potential: Chilling-sensitive with symptoms including pitting of the skin, interior discoloration, red blotch and loss of juice. Should not be stored for prolonged periods below 50°F (10°C) although 3-4 weeks at 37-41°F (3-5°C) should cause no harm. Moderate to severe chilling-injury is usually followed by decay.
- Shelf life: 6 months

# Lemons

## PESTS/DISEASES

Various pathogens: Green and blue mold are caused by *penicillium digitatum* and *P. italicum*, respectively. Spores access fruit rind through wounds. Symptoms begin as water-soaked areas at fruit surface followed by growth of colorless mycelium. Blue mold is more common when storage temperatures are low and spreads from fruit to fruit more readily than green mold.

- Thiabendazole, imazalil and sodium ortho-phenylphenate fungicides can be used.
- Partial control can be obtained with biological control agents and immersion of fruit in soda ash or sodium bicarbonate.
- Careful handling to minimize wounds is recommended.

Sour Rot: Enters through wounds made by insects. Infected fruit are then digested by the pathogens and it spreads rapidly. Associated with cool, wet growing conditions.

- Partial control is obtained by immersion of fruit in soda ash, sodium bicarbonate, or sodium ortho-phenyl phenate after harvest.
- Use optimum storage temperatures.

Other pathogens: Include *Alternaria citri*, the stem-end rot fungi *Diplodia natalensis* as well as *Phomopsis citri*, *Botrytis cinerea*, *Trichoderma spp.*, *Sclerotinia sclerotiorum*, and *Phytophthora spp.*

- Promptly cool fruit to the proper temperature range.
- Maintain optimum ranges of temperature and RH.
- Exclude ethylene during transport and storage.
- Use gibberelic acid before harvest to delay senescence of fruit after harvest.
- Sanitize throughout the handling system.

## Lettuce



### HARVEST

Quality: Head lettuce should be solid, with no seed-stem, defects, or decay. In general, high-quality lettuce should be clean, free of browning, be crisp and turgid, and bright light green.

Harvest tips:

- *Harvest early or when cool. Wetness is okay.*
- *Use a field knife to harvest.*
- *Harvest into a container holding 24 heads.*
- *Damaged or yellow leaves should be removed.*
- *Cut above ground to keep knife clean and remove only the good portion – a good picker will not have to retrim.*
- *Wipe field knife with cloth when soiled to keep cuts clean.*
- *Be careful not to handle roughly.*
- *Cut open several heads to make sure there is no tip burn (brown on edges of internal leaves)*

### HANDLING/PACKING

Grades: Dec. 1, 1975

- **U.S. Fancy:** Similar varietal characteristics, fresh, green, not soft, and not burst. Free from decay, russet spotting, and doubles. Free from injury by tip burn, downy mildew, field freezing, discoloration, and not damaged by any other cause. Each head shall be fairly well trimmed unless specified as closely trimmed. Tolerance at shipping point: 8% (5% for soft heads, 4% for serious damage, and 1% for decay on any part exclusive of the wrapper leaves).
- **U.S. No. 1:** Similar varietal characteristics, fresh, green, not soft, and not burst. Free from decay and doubles. Not damaged by any other cause. Each head shall be fairly well trimmed unless specified as closely trimmed. Tolerance at shipping point: 8% (5% for soft heads, 4% for serious damage, and 1% for decay on any part exclusive of the wrapper leaves).
- **U.S. No. 2:** Similar varietal characteristics, not burst, free from decay, and not seriously damaged by any other cause. Unless otherwise specified each head shall be reasonably trimmed. Tolerance at shipping point: 8% (3% for decay on any part exclusive of the wrapper leaves).

Cooling: Hydro-cooling; *set heads upside-down to drip dry.*

Washing: Wash in sanitized water.

Carton sizes:

Pack 24 heads in waxed leafy greens or 1 <sup>3</sup>/<sub>4</sub> bu. carton.

# Lettuce

**Weights:**

- Crisphead: 24-count cartons
- Leaf lettuce: 20-25-lb. cartons
- Butterhead/Boston: 20-lb. cartons
- Bibb/greenhouse-grown: 10-lb. cartons

**STORAGE**

- Temperature: 32°F (0°C)
- Humidity: 98-100%
- Respiration: 3-8 mL/kg hr at 32°F (0°C) for head lettuce; 9-13 mL/kg hr for leaf lettuce
- Air composition: 1-3% O<sub>2</sub>
- Ethylene producer: Low. Can be damaged by ethylene exposure
- Damage potential: *Do not allow to overheat*
- Shelf life: *2 weeks maximum*

**PESTS/DISEASES**

Various rots: Bacterial soft rot, gray mold rot, and *Sclerotinia*. Causes slimy breakdown of tissue.

- Avoid bruising leaves.
- Trim heads properly.
- Store at 32°F (0°C).



## Limes

### HARVEST

Harvest maturity: Persian lime (i.e., Bearss or Tahiti, *Citrus latifolia* Tan.) is the principle type grown commercially in the U.S. These limes must attain a size of 1.87" (4.76cm) in diameter and a juice content of 42%.

Quality: Should be oval, firm, with smooth peel and deep green (Persian) or green and/or yellow (Key lime) color. Limes should be turgid and free from decay, splitting, and blemishes.

Harvest tips:

- Oleocellosis can develop on the peel if hand harvest begins early in the morning or immediately after rainfall when the peel is turgid.



### HANDLING/PACKING

Grades (Persian/Tahiti lime): May. 31, 2006

- **U.S. No. 1:** Firm, fairly well formed with normal characteristic shape and not materially flattened on one side, of fairly smooth texture with fruit comparatively free from lumpiness and pebbling that is not abnormally coarse. Coarse pebbling is not objectionable as it indicates good keeping quality and likely fruit obtained from young trees. Limes shall be free from decay, styler-end tissue breakdown or other internal discoloration, broken skins that are not healed, bruises (except those incident to proper handling and packing), hard or dry skins. Fruit shall be free from damage caused by freezing, dryness or mushy condition, sprayburn, exanthema (ammoniation), scars, thorn scratches, scale, sunburn, scab, blanching, yellow color, discoloration, buckskin, dirt or other foreign material, disease, insects or mechanical or other means. Each fruit shall have not less than an aggregate area of  $\frac{3}{4}$  of the surface showing good green color characteristic of the Persian lime. Lots of limes that fail to meet the U.S. No. 1 requirements only because of blanching may be designated as U.S. No. 1, Mixed Color. Lots of limes that fail to meet the U.S. No. 1 requirements only because of blanching may be designated as U.S. No. 1, Mixed Color. Lots of limes that fail to meet the U.S. No. 1 or U.S. No. 1 Mixed Color requirements only because of turning yellow or yellow color, caused by the ripening process, may be designated as U.S. No. 1, Turning. Juice content shall not be less than 42%, by volume or weight. Tolerances: 10 % for color, 10% for remaining requirements (5% for decay, styler- end breakdown, broken skins which that are not healed, or defects causing serious damage including 0.5% for decay at shipping point, provided, that an additional tolerance of 2  $\frac{1}{2}$ % or a total of not more than 3% for decay en route or at destination).
- **U.S. Combination:** Combination of U.S. No. 1 and U.S. No. 2 limes with at least 60%, by count, of the limes in the lot meeting the requirements of U.S. No. 1 grade. U.S. No. 1 limes shall meet the color requirements of the U.S. No. 1 grade and the U.S. No. 2 limes shall meet the color requirements of the U.S. No. 2 grade. Lots of limes that fail to meet the U.S. Combination grade requirements only because of blanching may be designated as U.S. Combination, Mixed Color. Lots of limes which that fail to meet the U.S. Combination or U.S. Combination Mixed Color grade requirements only because of turning yellow or yellow color, caused by the ripening process, may be designated as U.S. Combination, Turning. Tolerances: 10% for color, 10% for remaining requirements of the lower grade in the combination (5% for decay, styler- end breakdown, and broken skins that are not healed, including 0.5% for decay at shipping point, provided, that an additional tolerance of 2  $\frac{1}{2}$ %, or a total of not more than 3%, shall be allowed for decay en route or at destination). No part of the above tolerances shall be allowed to reduce for the lot as a whole, the 60% of U.S. No. 1 limes required in the U.S. Combination grade, but individual containers may have not have less than 50% of the higher grade.
- **U.S. No. 2:** Fairly firm where fruit are not soft or excessively flabby, not badly deformed, and not excessively rough in texture with skin badly ridged or very decidedly lumpy. Fruit shall be free from

## Limes

decay, stylar-end breakdown or other internal discoloration, broken skins that are not healed, bruises (except those incident to proper handling and packing), and hard or dry skins, and free from serious damage caused by mechanisms outlined as per U.S. No. 1 grade above. Each fruit in this grade shall have not less than an aggregate area of  $\frac{1}{2}$  of the surface showing good green color characteristic of the Persian lime. Lots of limes that fail to meet the U.S. No. 2 requirements only because of blanching may be designated as U.S. No. 2, Mixed Color. Lots of limes which that fail to meet the U.S. No. 2 or U.S. No. 2 Mixed Color requirements only because of turning yellow or yellow color, caused by the ripening process, may be designated as U.S. No. 2, Turning. Fruit shall have a juice content not less than 42%, by volume or weight. Tolerances: 10% for color, 10% for remaining requirements (5% for decay, stylar-end breakdown, and broken skins that are not healed, including 0.5% for decay at shipping point, provided, that an additional tolerance of 2  $\frac{1}{2}$ %, or a total of not more than 3%, shall be allowed for decay en route or at destination).

- **Unclassified**

**Carton sizes:** All “standard” packages shall be well filled but the contents shall not show excessive or unnecessary bruising because of over-filled packages. Not more than 10% of fruit in any container may vary more than  $\frac{1}{4}$ ” diameter. Not more than 5% of the packages in any lot may fail to meet the requirements of the standard pack.

**Weights** (Persian limes): 10-lb. (4.5kg), 20-lb. (9.1kg) and 40-lb. (18.2kg) cartons

**Sizes** (Key limes): No size requirements or grades for Key limes, but juice content must be 42% by volume.

**Cooling:**<sup>9</sup>

- Hydro-cooling
- Forced-air cooling
- Room cooling

**Washing:**<sup>9</sup> Brush wash with soap/detergent if necessary

### STORAGE

- Temperature: 50°F (10°C)
- Humidity: 95%
- Respiration: < 10 mg CO<sub>2</sub>/kg hr at 50°F (10°C)
- Air composition: CA storage can retard senescence but commercial use is limited
- Ethylene producer: Low
- Damage potential: Chilling-injury, characterized by peel pitting, can result from storing below optimum storage temperatures
- Shelf life: 8 weeks

### PESTS/DISEASES

**Stem-end rot:** Key lime is very susceptible to *Diplodia natalensis* and Anthracnose (*Colletotricum*). Stem-end rots caused by *D. natalensis*, *Phomopsis citri*, and *Alternaria citri* are important postharvest diseases in Persian limes.

**Green and blue mold:** Enters through wounds made during harvesting and handling and appear in storage.

- Careful handling to minimize damage will reduce green and blue mold incidence.
- Use proper sanitation of packing line equipment.
- Use postharvest fungicides.

## Longon



### HARVEST

Harvest maturity: Maturity is judged by shape, skin color and flavor of each cultivar. Most fruit can be picked from a tree with one harvest, unless multiple flowerings have occurred. No definite harvest index exists, but growers usually note changes in skin appearance: mature fruit develop a smooth and relatively darker skin.

Quality: Shell color, size and shape, seed size and sweetness are criteria. Fruit should be free of insect damage and skin blemishes. Cull while sorting for size.

#### Harvest tips:

- Fruit are clipped from stem as hand removal can lead to inadvertent skin removal.
- Fumigation with SO<sub>2</sub> to prevent skin browning and to control postharvest disease is very effective but is not approved for use in the U.S. for fruit to be sold fresh.
- Asian consumers prefer longan in bunches. They assume that single fruit are from dropped bunches or that they are not fresh. Single fruit may have a higher rate of weight loss.

### HANDLING/PACKING

Grades: Longons are not graded in the U.S.

Carton sizes: One piece fiberboard crates are used, either 10-lb. (4.5kg) or 5-lb. (2.25kg) with plastic liners, if not already packed in polystyrene containers.

#### Cooling:

- Room cooling
- Forced-air cooling
- Hydro-cooled (in plastic baskets)

### STORAGE

- Temperature: 41-46°F (4-7°C)
- Humidity: 90-95%. Desiccation rapidly leads to a dull brown skin color
- Respiration: 1.8-5.8 mL CO<sub>2</sub>/kg hr at 41°F (5°C)
- Air composition: No controlled atmosphere studies have been reported
- Ethylene producer: Low. There are no reports on ethylene sensitivity
- Damage potential: The dark brown peel that develops at very low temperatures is regarded as chilling-injury. Occurs at 32°F (0°C) in non SO<sub>2</sub>-fumigated longans. At storage temperatures <41°F (5°C), a slight off-flavor can develop after 1 week.
- Shelf life: 2-3 weeks although skin becomes brown over time

### PESTS/DISEASES

Various fungi: *Lasiodiplodia theobromae*, *Pestalotiopsis sp.*, *Cladosporium sp.*, *Fusarium sp.* and *Aspergillus niger* cause skin browning and darkening along with mycelium.

## Loquat



### HARVEST

Harvest maturity: Quality is highly dependent on the degree of ripening. Loquats harvested in the fully ripe stage have optimum quality. However, in commercial situations where transport and shelf-life are involved, loquats are generally harvested at the “eating-ripe” stage before becoming fully ripe. In most cultivars, harvest date is determined by skin color changes.

Quality: High quality loquats have SSC >12%, moderate TA (0.3-0.6%) and low flesh firmness. Loquat cultivars have a rapid rate of fruit softening.

Harvest tips:

- Must be handled with care to avoid mechanical damage as fruit are easily bruised and scratched and the damaged areas usually turn brown or black.
- Low-temperature storage is essential for extending postharvest life.

### HANDLING/PACKING

Grades: Loquats are not graded in the U.S.

Carton sizes: Packages commonly employ soft materials because of bruising susceptibility.

Sizes (Tanaka variety):

- Large: > 2.1-oz. (60g)
- Medium: 1.9-oz. (50-59g)
- Small: 1.6-oz. (40-49g)
- SS: 1.2-oz. (30-39g)

Cooling: Pre-cool to <41°F (<5°C) within 20 hr of harvest.

### STORAGE

- Temperature: 32-41°F (0-5°C)
- Humidity: >90%
- Respiration: Influenced by temperature and decreases rapidly over the first 4 days of storage. By day 4, respiration rates of fruit stored at 68, 50 and 41°F are 44.4, 16.1, 6.4 mL/kg hr respectively.
- Air composition: No information available
- Ethylene producer: Low. Not particularly sensitive to ethylene exposure
- Damage potential: Not sensitive to chilling temperatures
- Shelf life: 3-4 weeks at 32°F. Use of polyethylene bags retards weight loss and minimizes loss of organic acids. Internal browning and brown surface spotting can occur during long-term (or high CO<sub>2</sub> storage)

### PESTS/DISEASES

Cooling fruit and keeping at <41°F is effective in controlling spoilage.

## Lychee (Litchi)



### HARVEST

Harvest maturity: Red skin color and flesh that has the optimum range of sugar to acid ratio for the cultivar. During maturation, the acid level declines and sugar level increases. Fruit do not continue to ripen after harvest.

Quality: Skin color and fruit size. Internal criteria are seed size and flesh sweetness/juiciness. A bright red fruit with no browning is preferred along with freedom from bird, insect and mechanical damage, cracking and decay.

Harvest tips:<sup>10</sup>

- Need to carefully sort before storage to remove any damaged/decayed fruit or fruit with insect stings.
- Clip fruit from panicles to minimize bruising and decay.

### HANDLING/PACKING

Grades: Lychees are not graded in the US.

Carton sizes: One piece fiberboard boxes 5-lb. (2.25kg) or 10-lb. (4.5kg) with polyethylene film liners. Fruit are also packed into 0.5 pint (0.12L) styrene containers.

Cooling:<sup>10</sup>

- Room cooling
- Hydro-cooling

Washing:<sup>10</sup> Can be done as part of hydro-cooling if necessary

### STORAGE

- Temperature: 36-41°F (2-5°C)
- Humidity: 90-95%
- Respiration: 5.1-8.2 mL CO<sub>2</sub>/kg hr at 41°F (5°C)
- Air composition: 3-5% O<sub>2</sub> and 5% CO<sub>2</sub> is recommended at 41-45°F (5-7°C)
- Ethylene producer: Low. Ethylene exposure may lead to early aril deterioration
- Damage potential: Low sensitivity to chilling temperatures. However, dehydration during storage often leads to loss of skin color and browning and is referred to as chilling-injury. Higher levels of CO<sub>2</sub> (10-15%) can lead to off-flavors.
- Shelf life: 3-5 weeks

### PESTS/DISEASES

Various disease organisms: *Aspergillus spp.*, *Pestalotiopsis spp.*, *Peronophythora spp.*, sour rot caused by *Geotrichum candidum* and yeasty rots. Other organisms found to cause rots include *Botryodiplodia theobroma*, *Colletotrichum gloesporioides* and *Rhizopus oryzae*. Most have their origins pre-harvest.

- Use good field sanitation.
- Cull fruit that shows piercing from insects, cracks, and sun-scorch damage.

## Mangoes



### HARVEST

**Harvest maturity:** For most cultivars, mangos are mature when fruit shoulders have risen above the stem-end and there is a slight skin color break on the first fruit of a crop. Early fruit from a single flowering should only be harvested after a slight skin color change. Two weeks later, all full-size fruit can be harvested, even if there is no apparent skin color change. Other indices include: SSC and TA, fruit specific gravity and days from blooming.

**Quality:** Skin coloration, size, shape for variety, appearance, absence of fiber in the flesh and a turpentine-like flavor are the most common quality parameters. Wilted, grayish discoloration and pitting are undesirable. Some fruit varieties (Haden) have pinhead-size black spotting that is not regarded as a defect.

#### Harvest tips<sup>11</sup>

- Fruit should be twisted, sharply sideways or upward, to break the pedicel.
- To avoid stem punctures, long pedicels should be trimmed flush with stem-end of fruit.
- A picking pole with clothbag and knife on top can be used for fruit on high branches.

### HANDLING/PACKING

**Grades:** Aug. 24, 2007

- **U.S. Fancy:** Similar varietal characteristics, mature, clean, well formed with the shape being typical of the variety, symmetrical without irregularities in shape and well trimmed, having a neatly clipped stem or broken off at a point not more than 1" beyond the point of attachment. Fruit shall be free from decay, not overripe, show no evidence of freezing injury, internal discoloration, insects and larva or their damage, skin breaks which are not healed, and shall be free from injury by healed skin breaks, bruising, scab, shriveling, external (surface) discoloration, sunken discolored areas, scars, russeting, other diseases, or mechanical or other means. Tolerances: 10% (5% for defects causing damage and 2% for decay).
- **U.S. No. 1:** As for U.S. Fancy but may be fairly well formed with the shape being typical of the variety and symmetrical, with slight irregularities in shape allowed, but not to the extent where appearance is materially affected. Fruit shall be free of skin breaks which are not healed and extend into the flesh and be free from damage caused by the injury mechanisms outlined in the U.S. Fancy grade above. Tolerances: 10% (5% for defects causing serious damage and 2% for decay).
- **U.S. No. 2:** As for US No. 1 but shall be free from serious damage caused by the injury mechanisms outlined in the U.S. Fancy grade. Tolerances: 10% (2% for decay).

**Carton sizes:** Sold in 35-lb. (16kg) cartons, 14-lb. (6kg) flat single-layer cartons and 10-lb. (4.5kg) single-piece fiberboard boxes with various counts.

**Cooling:** Pre-cool, preferably within 24 hr of harvest.

- Forced-air
- Room cooled

**Washing:** Water/detergent washing helps to avoid damage from sap burn in susceptible cultivars (e.g., Kensington variety).

## Mangoes

### STORAGE

- Temperature: 50-55°F (10-13°C). Ripe fruit can be stored at 44.6-46.4°F (7-8°C).
- Humidity: 85-90%
- Respiration: 12.1-24.2 mL/kg hr at 50°F (10°C). Increases 3-5 fold if fruit heated for insect disinfestation. Rates remain higher than those of unheated fruit for 4-6 days.
- Air composition: 3-5% O<sub>2</sub> and 5-10% CO<sub>2</sub> at 44.6-48.2 °F (7-9 °C). Polyethylene or other film bags, with and without an ethylene absorber, give some delay in ripening but may lead to off-flavors and abnormal skin coloration. Ripening delays are minor and may not be economic in all situations.
- Ethylene producer: Moderate. Induces faster and more uniform softening. There is some disagreement in the literature regarding ethylene treatment effects on quality.
- Damage potential: Chilling-injury below 50°F (10°C), especially if fruit have just reached maturity. Symptoms include grayish, scald-like discoloration on the skin, followed by pitting, uneven ripening and poor flavor and color development. Susceptibility varies, with Haden and Keitt cultivars being particularly sensitive. Heat treatment prior to storage reduces injury in Keitt variety.
- Shelf life: 14-28 days for mature green fruit depending upon variety

### PESTS/DISEASES

Anthraxnose (*Colletotrichum gloesporioides*): Appears as fruit ripen firstly as superficial black spots and streaks that then become sunken.

Stem end rot: Caused by several fungi that infect fruit before and after harvest.

Alternaria rot: (*Alternaria alternata*): A pre-harvest infection that can be problematic.

Black Mold (*Aspergillus spp.*): A postharvest wound infection

Transit rot (*Rhizopus spp.*): A postharvest wound infection

- Use good field and postharvest sanitation.
- Avoid latex burn (stain) and mechanical injury.
- Treat with hot water (115°F) for 60-120 min and fungicides can be used, depending on cultivar. Also hot water brushing at 131°F (55°C) for 20 s.

## Mushrooms



### HARVEST

**Harvest maturity:** Harvested by maturity, not by size of caps. Maturity is reached when caps are well rounded and the partial veil is completely intact. The stipe should have a small length to thickness ratio and should be sufficient to permit some trimming without cutting caps.

**Quality:** Based on maturity, size, trimming, freedom from open veils, absence of browning or other discoloration, disease and injury. A uniform, well-rounded cap, with smooth glossy surface and fully intact veil, indicate high quality. Cap color should be white or dark brown and a stipe should be present.

### HANDLING/PACKING

**Grades:** Jul. 15, 1966

- **U.S. No. 1:** Similar varietal characteristics (should be of the same general color), mature, with the mushroom being firm and well developed (the veil area may be stretched but not broken) and at least fairly well shaped where the cap is not flattened, scalloped, indented or otherwise deformed to an extent which materially detracts from the appearance. Shall be well trimmed with stems smoothly cut, free from rough fleshy butts, with the flared portion of the butt removed and the remaining portion of the stem not exceeding the depth of the cap. Shall be free from open veils exposing the gills or underside of the cap, disease, spots, pitted or discolored areas, insect injury, decay and damage by any cause. Tolerances: Defects at shipping point: 5% (1% for disease, spots or decay). Defects en route or at destination: 10% for open veils, 5% for remaining requirements (1% for disease, spots or decay). For off-size: 10%.

**Sizes (diameter):**

Small to medium: up to 1.625"

Large: >1.625"

- **U.S. No. 2:** Same as for U.S. No. 1 except a greater tolerance for open veils and defects is allowed. Tolerances: Defects at shipping point: 10% for open veils, 10% for remaining requirements of the grade (1% for disease, spots or decay). Defects en route or at destination: 25% for open veils, 10% for remaining requirements (1% for disease, spots or decay). For off-size: 10%.
- **Unclassified**

**Cooling:** Pre-cool to 32-39 °F (2-4 °C) immediately after harvest. Mushrooms have a greater shelf life if immediately packed and vacuum-cooled and then transported at a low temperature.

- Hydro-cooling
- Forced-air cooling
- Vacuum-cooling

**Washing:** Not recommended.

**Materials:** Pack in trays or cartons with a perforated polyethylene film over-wrap to reduce moisture loss. It is important to avoid water condensation inside packages.



# Mushrooms

## STORAGE

- Temperature: 32-33.8°F (0-1°C).
- Humidity: 95%. Essential to prevent desiccation, loss of glossiness, stipe blackening and veil opening.
- Respiration: 14-22 mL/kg hr at 32°F (0°C)
- Air composition: 3-21% O<sub>2</sub> and 5-15% CO<sub>2</sub>. Low O<sub>2</sub> and high CO<sub>2</sub> inhibits cap opening, internal browning and stipe elongation, but may cause yellowing of the cap surface.
- Ethylene producer: Very low. Ethylene exposure causes browning of mushroom caps.
- Damage potential: Not chilling-sensitive, but will freeze below 31°F (-0.6°C) resulting in water-soaked and extremely soft caps.
- Shelf life: 7-9 days (12-15 days under CA conditions) for fresh mushrooms

## PESTS/DISEASES

Disease is generally not an important source of postharvest loss compared with physiological senescence and improper handling or bruising.

- All diseased caps must be eliminated at harvest.

Bacterial blotch (*Pseudomonas spp*): Can become a problem during extended storage at elevated temperatures.

## Napa (Chinese) Cabbage



### HARVEST

Harvest maturity: Grown in small acreages and is available year-round in most markets. Determination of maturity is not simple and no single indicator is reliable. Harvesting consists of cutting the whole plant at the soil surface when the heads are firm and the outer leaves are bright green. With some cultivars, the outer leaves may be tied a few weeks before harvest to promote a tighter, upright head.

Quality: Uniform, tightly formed heads with yellow-green, crinkly leaf blades. There should be no evidence of leaf wilting or discoloration.

Harvest tips:

- Any damaged leaves should be removed prior to storage.
- Storage-life is extended by growing Chinese cabbage during cooler growing seasons and placing the heads upside down during storage.
- Chinese cabbages store better when heads are more compact at harvest.

### HANDLING/PACKING

Grades: Chinese cabbages are not graded in the U.S.

Cooling: Pack into shipping containers and quickly cool

- Vacuum-cooling and hydro-vacuum cooling
- Hydro-cooling
- Forced-air cooling

Washing: Not recommended.

Carton sizes:

**Weights:** 2.2-9.9 lb (1-4.5 kg)

Materials: Shipped in wax-coated corrugated cardboard cartons and wire-bound crates of various sizes. Water loss can be reduced and storage-life extended if heads are stored in perforated polyethylene bags

### STORAGE

- Temperature: As close as possible to 32°F (0°C) without freezing
- Humidity: 98-100%
- Respiration: 3-7 mL/kg hr at 32°F (0°C)
- Air composition: 1-2% O<sub>2</sub> and 0-5% CO<sub>2</sub> depending on cultivar, temperature and storage duration. If conditions are optimized, green color, ascorbate and sugar content in leaves is retained and decay development is decreased
- Ethylene producer: Very low. Highly sensitive to ethylene exposure
- Damage potential: Cultivars differ in chilling sensitivity. "Brown midrib" may develop injury after prolonged storage at 32°F (0°C). Elevated levels of CO<sub>2</sub> can increase decay and offensive odors.
- Shelf life: 3-6 months depending on cultivar

### PESTS/DISEASES

Alternaria spp: Causes leaf spots

Bacterial soft rot (Erwinia carotovora)

Xanthomonas campestris: Possible black discoloration of leaf veins

- Store at optimum temperature and atmospheric conditions.

## Nectarines



### HARVEST

**Quality:** Greater consumer acceptance is attained for fruit with high SSC. TA and SSC:TA are also important for consumer acceptance. Fruit <27 N (6 lb-force) firmness are highly accepted by consumers (*as long as the fruit is not immature*).

**Harvest tips:**

- *Should be picked just slightly underripe for ease of handling.*
- *Handle very gently.*

### HANDLING/PACKING

**Grades:** Mar. 29, 2004

- **U.S. Fancy:** Of one variety that are mature but not soft or overripe, that are well formed, clean, and free from decay, broken skins that are not healed, worms, and worm holes, and free from injury caused by bruises, growth cracks, hail, sunburn, sprayburn, scab, bacterial spot, scale, split pit, scars, russeting, other disease, insects, or mechanical or other means. Each nectarine shall have not less than  $\frac{1}{3}$  of its surface showing the red color characteristic of the variety. Tolerance at shipping point: 8% (4% for serious damage and 0.5% for decay).
- **U.S. Extra No. 1:** Of one variety that are mature but not soft or overripe, that are well formed, clean, and free from decay, broken skins that are not healed, worms, and worm holes, and free from injury caused by split pit, and damage caused by bruises, growth cracks, hail, sunburn, sprayburn, scab, bacterial spot, scale, scars, russeting, other disease, insects, or mechanical or other means. At least 75% of the nectarines in any lot shall show some blushed or red color including therein at least 50% of the nectarines with not less than  $\frac{1}{3}$  of the fruit surface showing the red color characteristic of the variety. Tolerance at shipping point: 8% (4% for serious damage and 0.5% for decay).
- **U.S. No. 1:** Of one variety that are mature but not soft or overripe, that are well formed, clean, and free from decay, broken skins that are not healed, worms, and worm holes, and from injury caused by split pit, and from damage caused by bruises, growth cracks, hail, sunburn, sprayburn, scab, bacterial spot, scale, scars, russeting, other disease, insects, or mechanical or other means. Tolerance at shipping point: 8% (4% for serious damage and 0.5% for decay).
- **U.S. No. 2:** Of one variety that are mature but not soft or overripe, that are not badly misshapen, that are clean and free from decay, broken skins that are not healed, worms, and worm holes, and free from serious damage caused by bruises, growth cracks, hail, sunburn, sprayburn, scab, bacterial spot, scale, split pit, scars, russeting, other disease, insects, or mechanical or other means. Tolerance at shipping point: 8% (4% for sunscald or serious damage by insects or heat injury and 0.5% for decay).

**Cooling:** Cooling to 41-50°F (5-10°C) is adequate if packing occurs the next day. Otherwise fruit should be cooled to 32°F (0°C).

- Forced-air cooling
- Hydro-cooling (conveyor type hydro-cooler, or *in situ*)

**Washing:** May be washed in sanitized water.

# Nectarines

Carton sizes:

- 2-layer tray boxes (yellow-fleshed)
- 1-layer tray boxes (white-fleshed)

Materials: Fruit should be handpicked into bags, baskets or totes. If totes are used, they should be placed directly in bins.

## **STORAGE**

- Temperature: 30-32°F (-1-0°C)
- Humidity: 80-85%
- Respiration: 2-3 mL/kg hr at 32°F (0°C)
- Air composition: 3-5% CO<sub>2</sub>, 1-2% O<sub>2</sub>
- Ethylene producer: 0.01-5 µL/kg hr; exposure to ethylene may help ripen mature stage fruit
- Damage potential: Moderately susceptible to chilling-injury
- Shelf life: 1-3 weeks

## **PESTS/DISEASES**

Brown rot: The most important postharvest disease of stone fruits.

- Use orchard sanitation to minimize infection sources.
- Apply pre-harvest fungicide.
- Cool promptly after harvest.

Gray mold: Can be serious during wet spring weather.

- Avoid mechanical injuries.
- Practice good temperature management.

Rhizopus rot: Occurs in ripe or near-ripe fruits held at 68-77°F (20-25°C).

- Cool fruit and keep them below 41°F (5°C).

Bacterial spot

## Nopalitos



### HARVEST

Harvest maturity: Harvested based on size. Over-mature nopalitos are thick with lots of spongy white tissue and are acidic in flavor.

Quality: Fresh, turgid and a brilliant green color. If true leaves remain on the stem and are green, this is an additional indication of freshness. Nopalitos should be harvested when young and tender, and not early in the morning so as to avoid high acid content.

Harvest tips:

- Cactus stems should be harvested and handled with care to avoid mechanical damage, especially due to spines from one stem penetrating neighboring stems. Spine damage leads to a rusty-brown discoloration and pathological problems.
- The acid content of nopalitos (especially medium sized or larger) may fluctuate greatly and affect flavor. Harvesting stems 2-3 hr after sunrise is recommended.
- Low temperature storage at 41 °F (5°C) maintains acid levels, while warmer storage conditions (59-68°F [15-20°C]) result in decreased acid levels.

### HANDLING/PACKING

Grades: Nopalitos are not graded in the U.S.

Cooling: Nopalitos should be cooled to about 41°F (5°C)

- Room cooling
- Forced-air cooling

Washing: Not recommended

Carton sizes: Typically loose packed in 10-20 lb. (4.5-9.0kg) cartons or boxes based on size and quality.

Sizes:

- Small: <4" (10cm) long
- Medium: <8" (20cm) long and are about 0.2-lb. (100g) in weight

### STORAGE

- Temperature: 41°F (5°C)
- Humidity: 95-99%. Under ambient conditions nopalitos rapidly lose their shiny appearance, become dull-green and yellow and curve inward due to water loss.
- Respiration: 8.2-9.7 mL CO<sub>2</sub> /kg hr at 41°F (5°C)
- Air composition: No information available
- Ethylene producer: Very low. Not sensitive to ethylene exposure
- Damage potential: Chilling damage may occur if stored > 3 weeks at 41°F (5°C) resulting in superficial bronzing or discoloration and increased susceptibility to decay.
- Shelf life: 3 weeks

### PESTS/DISEASES

Decay: May be a problem at the cut stem-end if nopalitos are stored >2 weeks.

- Ensure nopalitos are not damaged when cut from the plant.
- Fungicide dips can reduce postharvest decay but are not used commercially.

## Okra



### HARVEST

Quality: High quality pods are 2-6" (5-15 cm) long, flexible, bright-green and turgid. Seeds should not be protruding through the epidermis, and ridges should be free of blackening and bruising. Okra pods should be harvested when immature and high in mucilage, but before becoming highly fibrous; generally within 2-6 weeks after flowering.

### HANDLING/PACKING

Grades: Dec. 18, 1928

- **U.S. No. 1:** Pods of okra of similar varietal characteristics that are fresh, tender, not badly misshapen, free from decay, and from damage caused by dirt or other foreign matter, disease, insects, mechanical or other means. Tolerance: 10% (5% for serious damage and 1% for decay).
- **Unclassified**

Cooling: Okra should be marketed within 36 hr of harvest and shipped under refrigeration. Storage in unventilated containers without refrigeration can cause degradation of color. Some growers use hydro-cooling or forced-air cooling.

Washing: Okra should not be washed.

Carton sizes:

#### Weights:

- 1-lb. clamshell boxes
- Bulk weight or volume-filled 25-lb. bins

#### Sizes:

- Fancy: <math>3 \frac{1}{2}</math>"
- Choice:  $3 \frac{1}{2}$ "- $4 \frac{1}{4}$ "
- Jumbo:  $>4 \frac{1}{4}$ "

### STORAGE

- Temperature: 45-50°F (7-10°C)
- Humidity: >90%
- Respiration: 45-50 mL/kg hr at 50°F (10°C)
- Air composition: 4-10% CO<sub>2</sub>
- Ethylene producer: Low. Moderately sensitive to ethylene exposure
- Damage potential: Highly sensitive to chilling-injury
- Shelf life: 7-14 days

### PESTS/DISEASES

Multiple sources: Chladosporium, gray mold (*Botrytis cinerea*), mildew, yeasts, *Rhizopus stolonifer*, *Rhizoctonia solani*, and *Pseudomonas* pv *syringae*.

## Olives



### HARVEST

Harvest maturity: Green olives: maturity assessed by color; (even coloration, pale green with a minimum of whitish spots through to a straw color), size, and if it exudes a white juice when squeezed. Black olives: usually mature 3-4 months after green stage. Assessed by skin color and removal force. Over-mature fruit frequently spoils during processing.

Quality: Green olives: appropriate color, oil content (12-25% depending on cultivar), and being free of mechanical damage, shriveling, surface blemishes, scale, insect injury and decay. Black olives: color and freedom from defects.

Harvest tips:

- Fruit begin to lose moisture immediately after harvest. During hot, sunny weather, olives should be put in the shade while waiting to be hauled away. Sun-exposed fruit get sunburnt and will grade as culls.
- Rough handling causes bruises and grade reduction. An increasing number of growers harvest their fruit mechanically, using tree shakers and catching frames.

### HANDLING/PACKING

Grades: Olives are not graded in the U.S.

Cooling:<sup>12</sup> For fresh olives

- Forced-air cooling
- Room cooling

Washing: Fresh olives may be washed with sanitized water.

### STORAGE

- Temperature: 41-45.5°F (5-7.°C)
- Humidity: 90-95%
- Respiration: 5.1- 10.3 mL/kg hr at 41°F (5°C)
- Air composition: 2-3% O<sub>2</sub> and 0-1% CO<sub>2</sub> for green olives. 2% O<sub>2</sub> for black olives (but it is recommended that these be processed as soon after harvest as possible)
- Ethylene producer: Low. Moderately sensitive to ethylene. Causes a loss of green color and flesh firmness.
- Damage potential: Chilling-injury can occur at <41°F (5°C). Initial symptoms are a slight, tannish to brown discoloration in the flesh adjacent to the pit, followed by skin damage where olives appear as if they have been boiled. Susceptible to chilling-injury, from most to least: Sevillano, Ascolano, Manzanillo, and Mission varieties. For green olives, O<sub>2</sub> <2% can cause off-flavors and CO<sub>2</sub> >5% may increase severity of chilling-injury if olives are stored below 45.5°F.
- Shelf life: 12 weeks at 41°F (5 °C), 9 weeks at 45.5°F (7.5°C) for fresh green olives. 4 weeks for black olives under the air composition conditions described above.

### PESTS/DISEASES

Postharvest diseases: Occur if olives have been chilled at temperatures below 41°F (5°C), mechanically damaged, not cooled promptly after harvest to 41-45.5°F (5-7.5°C) or exposed to undesirable atmospheres (>5% CO<sub>2</sub> and/or <2% O<sub>2</sub>).

## Onions

### HARVEST

Quality: Mature bulbs with good firmness and compactness of fleshy scales. The size, shape and color of the dry skin should be typical for the variety. They should be free of mechanical or insect damage, decay, sunscald injury, greening of fleshy scales, sprouting, bruising, doubles, bottlenecks (onions which have abnormally thick necks with only fairly well developed bulbs) and any other defects.

Harvest tips:

- *Harvest when tops begin to dry naturally.*



### HANDLING/PACKING

Grades: Oct. 10, 1995

- **U.S. No. 1:** Similar varietal characteristics, mature, fairly firm, and fairly well shaped. Free from decay, wet sunscald, doubles, bottlenecks, and scallions. Free from damage caused by seedstems, splits, tops, roots, dry sunken areas, sunburn, sprouts, freezing, peeling, cracked fleshy scales, watery scales, dirt or staining, foreign matter, mechanical, translucent scales, disease, insects, and other means. Tolerance (Defects): 10% for damage by peeling, 5% for other grade requirements (2% for decay or wet sunscald). (Off-size): 5% may be below the specified minimum size, and not more than 10% may be above any specified maximum size, as outlined in the standard.
- **U.S. Commercial:** Similar varietal characteristics, mature, not soft or spongy, and not badly misshapen. Free from decay, wet sunscald, doubles, bottlenecks, and scallions. Free from damage caused by seedstems, tops, roots, dry sunken areas, sunburn, sprouts, freezing, cracked fleshy scales, watery scales, mechanical, translucent scales, disease, insects, and other means. Free from serious damage caused by staining, dirt, and other foreign matter. Tolerance (Defects): 5% for grade requirements (2% for decay or wet sunscald). (Offsize): As for U.S. No. 1.
- **U.S. No. 1 Boilers:** Same as U.S. No. 1 except for size. Tolerance (Defects): As for U.S. No. 1. (Offsize): As for U.S. No. 1.
- **U.S. No. 1 Picklers:** Same as U.S. No. 1 except for size. Tolerance (Defects): As for U.S. No. 1. (Offsize): 10% may be above the maximum size specified for this grade.
- **U.S. No. 2:** One type, mature, and not soft or spongy. Free from decay, wet sunscald, and scallions. Free from serious damage caused by watery scales, dirt or staining, foreign matter, seedstems, sprouts, mechanical, dry sunken areas, disease, freezing, insects, and other means. Tolerance (Defects): As for U.S. Commercial. (Offsize): As for U.S. No. 1.

Curing: *Field cure for 3-5 days as long as it doesn't rain, then put in a warm ventilated area to finish curing. Curing in the greenhouse works well.*

Cooling: Dry onion bulbs for long-term storage should be pre-cooled to 32°F (0°C) immediately after curing.

Washing: Dry brushing before or after storage. *Trim roots and stems after curing.*



## Onions

### Carton sizes:

### **Weights:**

- 20-lb. cartons
- 25-lb. or 50-lb. net bags

### **Sizes:**

- Small: 1 - 2 1/4"
- Prepacker: 1 1/2 - 3"
- Medium: 2" - 3 1/4"
- Large: 3" - 3 3/4"
- Colossal: >3 3/4"

### **STORAGE**

- Temperature: 68-86°F *for curing*; 32°F (0°C) for long-term storage
- Humidity: 65-75%
- Respiration: 1.5 mL/kg hr at 32°F (0°C)
- Air composition: 5% CO<sub>2</sub>, 3% O<sub>2</sub> can be used
- Ethylene producer: Very low. Not very sensitive to ethylene exposure, although high concentrations can induce sprouting.
- Damage potential: Low
- Shelf life: 6-9 months

### **PESTS/DISEASES**

Botrytis neck rot: Gray mold covers neck first, then the whole bulb.

- Dry onions properly.

#### Black mold rot

- Store at 32°F (0°C).
- Store with moderate humidity.

#### Blue mold rot

- Harvest only mature bulbs.
- Dry onions properly.
- Store at 32°F (0°C).
- Store with moderate humidity.

#### Bacterial soft rot

- Harvest only mature bulbs.
- Dry onions properly.
- Minimize bruising.
- Maintain optimum storage conditions.

## Oranges



### HARVEST

Harvest maturity: Maturity indices are based on percentage color break, SSC, TA, SSC:TA and/or juice content. Specific regulations are established for different growing regions.

Quality: Mature with good color intensity uniformly distributed over surface. Firm with fairly smooth texture and shape, characteristic of variety and free from decay and defects.

### HANDLING/PACKING

Grades (Texas and States other than Florida, California and Arizona):  
Sept. 5, 2003

Tolerances: Please refer to Table I within the standard for allowable defects at shipping point, and Table II for allowable defects en route or at destination. Note: No tolerance shall apply to wormy fruit.

- **U.S. Fancy:** Not more than  $\frac{1}{10}$  of the surface, in the aggregate, may be affected by discoloration. Shall be firm, have similar varietal characteristics, be well colored, well formed and have skin of a smooth texture. Fruit shall be free from ammoniation, bruises, buckskin, caked melanose, creasing, unhealed cuts, decay, growth cracks, scab, skin breakdown, sprayburn, undeveloped segments, wormy fruit and not injured by green spots, oil spots, split navels, rough, wide or protruding navels, scale, scars, thorn scratches and not damaged by any other cause.
- **U.S. No. 1:** Not more than  $\frac{1}{3}$  of the surface, in the aggregate, may be affected by discoloration and shall be firm, mature, with similar varietal characteristics, be well formed and have a fairly smooth texture. Early and midseason varieties shall be fairly well colored. For Valencia and other late varieties, not less than 50% shall be fairly well colored and the remainder reasonably well colored. Shall be free from bruises, unhealed cuts, caked melanose, decay, growth cracks, sprayburn, undeveloped segments, wormy fruit and not be damaged by any other cause.
- **U.S. No. 1 Bright:** Same as for U.S. No. 1 except that no fruit may have more than  $\frac{1}{10}$  of its surface, in the aggregate, affected by discoloration.
- **U.S. No. 1 Bronze:** Same as for U.S. No. 1 except that all fruit must show some discoloration. Not less than the number of fruits required in Tables I and II of the standard, shall have more than  $\frac{1}{3}$  of their surface, in the aggregate, affected by discoloration. The predominant discoloration on these fruits shall be of the rust mite type.
- **U.S. Combination:** Combination of U.S. No. 1 and U.S. No. 2 oranges provided that the number of U.S. No. 2 fruits specified in Tables I and II of the standard are not exceeded.
- **U.S. No. 2:** Not more than  $\frac{1}{2}$  of the surface, in the aggregate, may be affected by discoloration. Shall be fairly firm, mature, have similar varietal characteristics, be reasonably well colored and not more than slightly misshapen. Shall be not more than slightly rough and be free from bruises, unhealed cuts, decay, growth cracks, wormy fruit and not seriously damaged by any other cause.
- **U.S. No. 2 Russet:** Same as for U.S. No. 2 except that not less than the number of fruits required in Tables I and II of the standard, shall have more than  $\frac{1}{2}$  of their surface, in the aggregate, affected by discoloration.
- **U.S. No. 3:** Mature, have similar varietal characteristics, may be misshapen, may be slightly spongy, may have rough texture but not be seriously lumpy or cracked, may be poorly colored where not more than 25% of the surface may be of a solid dark green color. Fruit shall be free from unhealed cuts, decay, wormy fruit and not be very seriously damaged by any other cause.

**Sizes:** Please refer to Table III in the standard which outlines orange numbers and dimensions required for a standard  $\frac{7}{10}$  bushel carton. Not more than 5% of packages in any lot may fail to meet the requirements of the standard pack. Boxes, cartons, bag packs, or bulk loads in

# Oranges

which oranges are not packed according to a definite pattern do not meet the requirements of a standard pack, but may be certified as meeting standard sizing, provided the ranges are fairly uniform in size and not more than 5% of the containers in any lot fail to meet the requirements of standard sizing.

Grades (California and Arizona): Dec. 27, 1999

- **U.S. Fancy:** Similar varietal characteristics, mature, well colored, firm and well formed. Shall be of smooth texture and be free from decay, broken skins that are not healed, hard or dry skins, exanthema, growth cracks, dryness or mushy condition, and be free from injury caused by bruises, split, rough, wide or protruding navels, creasing, scars, oil spots, scale, skin breakdown, sunburn, dirt or other foreign material, disease, insects, or mechanical or other means.  
Tolerances: Defects at shipping point: 10% for color, 10% for remaining grade requirements (5% for defects causing serious damage and 1% for decay). Defects en route or at destination: 10% for color, 12% for remaining requirements (10% for permanent defects or 7% for defects causing serious damage, including 5% for serious damage by permanent defects and 3% for decay).
- **U.S. No. 1:** Same as for U.S. Fancy grade but may be of fairly smooth texture. Shall be free from decay and damage (as per mechanisms outlined in U.S. Fancy grade above). Each fruit shall be well colored except Valencia oranges which shall be at least fairly well colored and that navel oranges in any lot destined for export, and which are certified as meeting the standards for export, are fairly well colored. Tolerances: as for U.S. Fancy grade.
- **U.S. Combination:** Combination of U.S. No. 1 and U.S. No. 2 oranges, provided at least 40 % of the oranges in each lot meet the requirements of the U.S. No. 1 grade. Tolerances: Defects at shipping point: 10% for U.S. No. 2 grade requirements relating to color, 10% for remaining requirements of U.S. No. 2 grade (1% for decay). Defects en route or at destination: 10% for U.S. No. 2 requirements relating to color, 12% for remaining U.S. No. 2 requirements (10% for permanent defects and 3% for decay). Defects at shipping point and en route or at destination: No part of any tolerance shall be allowed to reduce for the lot as a whole, the 40% of U.S. No. 1 oranges required in the U.S. Combination grade, but individual samples may have not less than 30% of U.S. No. 1, provided that the entire lot averages within the percentage required.
- **U.S. No. 2:** Similar varietal characteristics, mature, fairly well colored, fairly firm and fairly well formed. Skin may be slightly rough in texture. Fruit shall be free from decay and serious damage (as per mechanisms outlined in U.S. Fancy grade above). Tolerances: Defects at shipping point: 10% for color, 10% for remaining grade requirements (1% for decay). Defects en route or at destination: 10% for color, 12% for remaining requirements (10% for permanent defects and 3% for decay).

**Sizes:** All containers shall be tightly packed and well filled but shall not show excessive or unnecessary bruising because of overfilling. When packed in cartons or in wire-bound boxes, each container shall be at least level full at time of packing. Oranges shall be fairly uniform in size, meaning that when oranges are packed for 113 carton count or smaller size, or equivalent, not more than 10%, of oranges in any sample may vary more than  $\frac{5}{16}$ " in diameter. When packed for sizes larger than 113 carton count or equivalent sizes packed in other containers, not more than 10% of oranges in any sample may vary more than  $\frac{7}{16}$ " in diameter. Not more than 5% of samples in any lot may fail to meet the requirements for the standard pack. Boxes or cartons in which oranges are not packed according to a definite pattern, do not meet the requirements of the standard pack, but may be certified as meeting the requirements of standard sizing and fill, provided the oranges are fairly uniform in size and the contents have been properly shaken down and the container is at least level full at time of packing. Not more than 5% of the samples in any lot may fail to meet the requirements of standard sizing and fill.

# Oranges

Grades (Florida): Feb. 20, 1997

- **U.S. Fancy:** Not more than  $\frac{1}{10}$  of the surface, in the aggregate, may be affected by discoloration. Shall be firm, mature, have similar varietal characteristics, a smooth texture and be well colored. Shall be well formed and free from ammoniation, buckskin, caked melanose, creasing, decay, scab, split navels, sprayburn, undeveloped segments, unhealed skin breaks, wormy fruit and be free from injury caused by bruises, green spots, oil spots, rough, wide or protruding navels, scale, scars, skin breakdown and thorn scratches. Fruit shall be free from damage caused by dirt or other foreign material, disease, dryness or mushy condition, hail, insects, riciness or woodiness, sunburn and other means. Tolerances: Defects at shipping point: 10%, (5% for defects causing very serious damage and 1% for decay or wormy fruit). Defects en route or at destination: 12%, (10% for permanent defects or 7% for very serious damage, including 5% for very serious damage by permanent defects and 3% for decay or wormy fruit).
- **U.S. No. 1 Bright:** Same as for U.S. No. 1 except that fruit shall have not more than  $\frac{1}{5}$  of its surface, in the aggregate, affected by discoloration. Tolerances (Defects): As for U.S. Fancy grade. (Discoloration): 10%. No sample may have more than 20% of fruit with excessive discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1:** Early and midseason varieties shall be fairly well colored. For Valencia and other late varieties, not less than 50% shall be fairly well colored and the remainder reasonably well colored. Not more than  $\frac{1}{3}$  of the surface, in the aggregate, may be affected by discoloration. Shall have fairly smooth texture, be firm, mature, have similar varietal characteristics, be well formed and be free from decay and damage (as per mechanisms outlined in the U.S. Fancy grade above). Tolerances (Defects): As for U.S. Fancy grade. (Discoloration): As for U.S. No. 1 Bright grade.
- **U.S. No. 1 Golden:** Same as for U.S. No. 1 except that not more than 30% shall have more than  $\frac{1}{3}$  of their surface, in the aggregate, affected by discoloration. Tolerances (Defects): As for U.S. Fancy grade. (Discoloration): Not more than 30% shall have in excess of  $\frac{1}{3}$  of their surface, in the aggregate, affected by discoloration and no part of any tolerance shall be allowed to increase this percentage. No sample may have more than 40% of fruit with excessive discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1 Bronze:** Same as for U.S. No. 1 except at least 30% of the fruit shall have more than  $\frac{1}{3}$  of their surface, in the aggregate, affected by discoloration. The main discoloration on each fruit shall be of the rust mite type. Tolerances (Defects): As for US Fancy grade. (Discoloration): At least 30% of the fruit shall have in excess of  $\frac{1}{3}$  of the surface, in the aggregate, affected by discoloration, and no part of any tolerance shall be allowed to reduce this percentage. No sample may have less than 20% of the fruit with the required discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1 Russet:** Same as for U.S. No. 1 except that at least 30% of fruit shall have more than  $\frac{1}{3}$  of their surface, in the aggregate, affected by any type of discoloration. Tolerances (Defects): As for U.S. Fancy grade. (Discoloration): As for US No. 1 Bronze.
- **U.S. No. 2 Bright:** Same as for U.S. No. 2 except that fruit shall have not more than  $\frac{1}{5}$  of their surface, in the aggregate, affected by discoloration. Tolerances (Defects): As for U.S. Fancy grade. (Discoloration): As for U.S. No. 1 Bright.
- **U.S. No. 2:** Not more than  $\frac{1}{2}$  of the surface, in the aggregate, may be affected by discoloration. Shall be fairly firm, mature, reasonably well colored, have similar varietal characteristics, be not more than slightly misshapen, and have not more than a slightly rough texture. Shall be free from decay, unhealed skin breaks and wormy fruit and be free from serious damage caused by the mechanisms outlined in the U.S. No. 1 grade. Tolerances (Defects): As for U.S. Fancy grade. (Discoloration): As for U.S. No. 1 Bright.

## Oranges

- **U.S. No. 2 Russet:** Same as for U.S. No. 2 except that at least 10% of the fruit shall have more than  $\frac{1}{2}$  of their surface, in the aggregate, affected by any type of discoloration. Tolerances (Defects): As for U.S. Fancy grade. (Discoloration): At least 10% of the fruit shall have in excess of  $\frac{1}{2}$  of the surface, in the aggregate, affected by discoloration, and no part of any tolerance shall be allowed to reduce this percentage and the entire lot shall average within the percentage specified.
- **U.S. No. 3:** Mature, with similar varietal characteristics, misshapen, poorly colored, can have a rough texture but is not seriously lumpy, and can be slightly spongy. Fruit shall be free from decay, unhealed skin breaks and wormy fruit, and be free from very serious damage caused by the mechanisms outlined in the U.S. No. 1 grade above. Tolerances: Defects at shipping point: 10%, (1% for decay or wormy fruit). Defects en route or at destination: 12%, (10% for permanent defects or 3% for decay or wormy fruit).  
**Sizes:** Fruit shall be fairly uniform in size: not more than 10% of oranges per sample may vary more than  $\frac{1}{2}$ " in diameter. Not more than 10% of the samples in any lot may fail to meet the requirements of size.

**Carton sizes:** Standard packed sizes used in Florida include 64, 80, 100, 125, and 163 fruit per 28.2-L ( $\frac{4}{5}$  bu) container. Standard packed sizes used in California include 24, 32, 36, 40, 48, 56, 72, 88, 113, 138, 163, 180, 210, 245, and 270 fruit per 28.5L container. Standard packed sizes used in Texas and States other than Florida, California and Arizona include 48 or 50, 64, 80, 100, 125, 144, and 162 fruit per 24.7L ( $\frac{7}{10}$  bu.) container.

**Cooling:** Rapid cooling will slow pathogen growth, reduce water loss and increase shelf-life.

- Room-cooling
- Forced-air cooling.

**Washing:**<sup>13</sup> Brush wash with soap/detergent if necessary.

**Materials:** Well-vented polyethylene and plastic mesh bags of various sizes are also used to market oranges. Carton design should include at least 5% side venting, designed to line up with adjacent carton vents to allow airflow through the entire load.

### STORAGE

Under normal weather conditions, fruit store better on the tree than in cold storage. Cold storage should not be attempted if the fruit storage potential has been expended by prolonged tree storage. Once harvested, fruit quality will not improve.

- Temperature: 32-34°F (0-1°C) for Florida and Texas growing region, 37-46°F (3-8°C) for California and Arizona
- Humidity: 85-90% for Florida and Texas, 90-95% California and Arizona

## Oranges

- Respiration: 1-3 mL/kg hr at 32°F (0°C)
- Air composition: 5-10% O<sub>2</sub> and 0-5% CO<sub>2</sub> although CA is not commonly used
- Ethylene producer: Very low. Used to degreen oranges, especially early in the season when natural degreening has been delayed because of warm night temperatures.
- Damage potential: California and Arizona oranges may develop chilling-injury when held at temperatures below about 37.4-41°F (3-5°C). Symptoms include pitting, brown staining, increased decay, internal discoloration, off-flavors and watery breakdown. Oranges produced in Florida or Texas rarely show chilling-injury.
- Shelf life: 12 weeks

### PESTS/DISEASES

**Fungal diseases:** Green mold (*Penicillium digitatum*), blue mold (*Penicillium italicum*), Diplodia stem-end rot (*Diplodia natalensis*), Phomopsis stem-end rot (*Phomopsis citri*), brown rot (*Phytophthora citrophthora*), sour rot (*Geotrichum candidum*) and Anthracnose (*Colletotrichum gleosporioides*). Growing region, production practices, cultivar, rootstock and postharvest practices influence susceptibility to each of these pathogens. E.g., stem-end rots are more prevalent in Florida and Texas. Green mold predominates in Florida, but blue mold in California.

- Harvest at optimum maturity.
- Gently handle fruit during harvest and postharvest operations.
- Maintain sanitary facilities and water handling systems.
- Promptly cool.
- Optimize temperature and humidity.
- Use approved fungicides or biological control agents.

## Papayas



### HARVEST

Harvest maturity: Fruit should have started ripening (as indicated by some skin yellowing) before harvest. Less mature fruit are lower in sugar and ripen poorly. Flesh is greenish-white in immature fruit to pale orange-yellow, salmon pink or red, depending on cultivar when ripe.

Quality: Size, shape, smooth skin and absence of blemishes are major quality characteristics. Consumers in Western countries also prefer fruit without the heavy musky, sweaty odor found in some Southeast Asian cultivars. Small dry brown-black “freckles” on the skin are non-pathogenic and do not detract from ripening or flavor. Fruit are marketed based on color break,  $\frac{1}{4}$ ,  $\frac{1}{2}$ , and  $\frac{3}{4}$  ripe and are normally ready to eat when there is 75% or more skin color on fruit.

Harvest tips:<sup>14</sup>

- Platforms or moveable worker stations can be used in place of ladders.

### HANDLING/PACKING

Grades: Papaya is not graded in the U.S.

Cooling:

- Room cooling
- Forced-air cooling

Washing:<sup>14</sup> May be washed in sanitized water. For decay control, fruit may be submerged for 20 mins in water at 114.8-122°F with vigorous circulation

Carton sizes: 10-lb. (4.5kg) cartons are common, although larger 22-lb. (10kg) cartons are also used. Cartons from areas requiring insect disinfestation are fully sealed to meet regulatory requirements, while fruit from other areas can be in open topped cartons. Count size ranges from 6 to 18, depending upon fruit and carton size.

Materials: Foam mesh sleeves, foam padding on the bottom of cartons or paper wrapping to prevent abrasion injury in fruit with areas of green skin.

## Papayas

### STORAGE

- Temperature: 45-55°F (7-13°C)
- Humidity: 90-95%
- Respiration: 2.1- 3.1 mL/kg hr at 41°F (5°C)
- Air composition: 2-5% O<sub>2</sub> and 5-8% CO<sub>2</sub> recommended, however no commercial use has so far been reported. One study indicated that fruit can be stored for 36 days in 8% CO<sub>2</sub> and 3% O<sub>2</sub> at 50°F (10°C) and still have 5 days of shelf life at retail temperatures of 77°F (25°C)
- Ethylene producer: Low. Ethylene ripening is not recommended commercially as rapid softening severely limits available marketing time.
- Damage potential: Chilling-injury symptoms include skin scald, hard lumps in the pulp and water soaking of flesh. Fruit become progressively less susceptible to chilling stress as they ripen.
- Shelf life: 14 days for fruit at color-turning (break) stage. Fruit will ripen normally when transferred to room temperature. Ripe, full color fruit can be held for > 1 week at 33.8-37.4°F (1-3°C)

### PESTS/DISEASES

Red and black mite (*Brevipalpus phoenicis* [Geijskes]): Feeding on skin during early fruit growth causes sunken, dry, brownish-gray areas.

Various fungi: Anthracnose, stem-end rot and Cercospora black spot become problematic especially at 25% or more skin yellowing. Rhizopus requires skin breaks for the disease to occur and causes deterioration especially when fruit is 40-60% yellow.

- Do not exceed 4 weeks storage at 50°F (10°C).
- Wash with hot water at 120°F (49°C) for 20 min.
- Treat with fungicide.
- Minimize mechanical and chilling-injury.



## Parsley



### HARVEST

Quality: Fresh, green color, free from defects and decay, and free from seed stems. Long petioles are desirable for bunching.

Harvest tips:

- Harvest during the cool part of the day.
- Bunch parsley with 1/3-lb. per bunch.

### HANDLING/PACKING

Grades: Jul. 20, 2007

- **U.S. No. 1:** Parsley of similar varietal characteristics and of good green color which is free from decay, and from damage caused or other foreign material, disease, insects, or mechanical or other means. Tolerance: 5% (0.5% for decay).

Cooling:

- Top-icing
- Hydro-cooling

Washing: No washing necessary

Carton sizes:

**Weights:** <sup>5</sup>/<sub>9</sub> bushel box with 30 bunches.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-100%
- Respiration: 11-16 mL/kg hr at 32°F (0°C)
- Air composition: 8-10% CO<sub>2</sub>, 8-10% O<sub>2</sub> (although this may have little benefit at 32°F [0°C])
- Ethylene producer: Very low. Sensitive to ethylene exposure
- Damage potential: Should not be allowed to overheat
- Shelf life: 2-3 weeks

### PESTS/DISEASES

Erwinia and Botrytis: Can cause postharvest damage from rots and mold.

## Parsnips



### HARVEST

Quality: Firm, reasonably clean and fairly smooth surfaced (not deeply ridged or with secondary rootlets). Parsnips are topped after harvesting but should not be trimmed into the crown.

Harvest tips:

- Loosen bed with bed lifter or field fork.
- Harvest into a field tote.

### HANDLING/PACKING

Grades: Dec. 10, 1945

- **U.S. No. 1:** Of similar varietal characteristics that are well-trimmed, fairly well formed, fairly smooth, fairly clean, fairly firm, free from woodiness, soft rot or wet breakdown, and from damage caused by discoloration, bruises, cuts, rodents, growth cracks, pithiness, disease, insects, mechanical or other means. Tolerance: 10% (5% for serious damage and 1% for soft rot or wet breakdown).
- **U.S. No. 2:** Well trimmed, not badly misshapen, free from woodiness, soft rot and wet breakdown, and from serious damage caused by secondary roots, dirt, discoloration, bruises, cuts, rodents, growth cracks, pithiness, wilting, disease, insects, mechanical or other means. Tolerance: 10% (1% for soft rot or wet breakdown).
- **Unclassified**

Cooling: Rapid cooling to 41°F (5°C) immediately after harvest is essential.

- *Forced-air on unwashed roots for long-term storage*

Washing: *Barrel wash for short-term storage. For long-term storage, wait until after storage to wash.*

Carton sizes:

**Weights:**

- 25-lb. <sup>5</sup>/<sub>9</sub> bushel waxed carton with perforated polyethylene liner

**Sizes:**

- Minimum diameter: 1.5"

### STORAGE

- Temperature: 32-34°F (0-1°C)
- Humidity: 98%
- Respiration: 4-8 mL/kg hr at 32°F (0°C)
- Air composition: Suspected to be of no benefit
- Ethylene producer: Very low. Very sensitive to ethylene exposure (small amounts cause bitterness)
- Damage potential: Low
- Shelf life: 4-6 months

### PESTS/DISEASES

Parsnip canker

- Some cultivars are resistant to parsnip canker.

Gray mold rot

Bacterial soft rot

Watery soft rot

## Peaches



### HARVEST

Quality: There is high consumer acceptance of peaches with high SSC. TA and SSC:TA are also important factors in consumer acceptance. For mid-season peaches, a minimum of 11% SSC with a TA  $\leq$  0.7% is required to satisfy about 80% of consumers.

### HANDLING/PACKING

Grades: May 21, 2004

- **U.S. Fancy:** Of one variety, mature but not soft or overripe, well formed and free from decay, bacterial spot, cuts that are not healed, growth cracks, hail injury, scab, scale, split pits, worms, worm holes, leaf or limb rub injury, and from damage caused by bruises, dirt or other foreign material, other disease, insects, or mechanical or other means. In addition to the above requirements, each peach shall have not less than  $\frac{1}{3}$  of its surface showing blushed, pink or red color. Tolerance at shipping point: 10% (5% for serious damage and 1% for decay).
- **U.S. Extra No. 1:** Same as U.S. No. 1, provided that 50% have not less than  $\frac{1}{4}$  of the surface showing blushed, pink or red color.
- **U.S. No. 1:** Of one variety, mature but not soft or overripe, well formed, and free from decay, growth cracks, cuts that are not healed, worms, worm holes, and from damage caused by bruises, dirt, or other foreign material, bacterial spot, scab, scale, hail injury, leaf or limb rubs, split pits, other disease, insects, or mechanical or other means. Tolerance at shipping point: 10% (5% for serious damage and 1% for decay).
- **U.S. No. 2:** Of one variety, mature but not soft or overripe, not badly misshapen, and free from decay, cuts that are not healed, worms, worm holes, and free from serious damage caused by bruises, dirt or other foreign material, bacterial spot, scab, scale, growth cracks, hail injury, leaf or limb rubs, split pits, other disease, insects, or mechanical or other means. Tolerance: 10% (1% for decay).

Cooling: Fruit in field bins can be cooled to 41-50°F (5-10°C) if packing is to occur the next day. Otherwise, fruit should be cooled to 32°F (0°C).

- Forced-air cooling
- Hydro-cooling

Washing: Dry brushing to remove fuzz *as long as fruit is not too ripe.*

Carton sizes:

### Weights:

- 2-layer tray boxes
- 10 bu. bulk box
- 1 bu. or  $\frac{1}{2}$  bu. box
- White-flesh and tree-ripened: 1-layer tray boxes

# Peaches

Materials: Fruit are hand-picked into bags, baskets or totes.

## **STORAGE**

- Temperature: 32-38°F (0-3°C)
- Humidity: 80-85%
- Respiration: 2-3 mL/kg hr at 32°F (0°C)
- Ethylene producer: 0.01-5.0 µL/kg hr for U.S. mature fruit
- Damage potential: Susceptible to chilling-injury
- Shelf life: 1-3 weeks

## **PESTS/DISEASES**

Brown rot: The most important postharvest disease affecting stone fruits.

- Orchard sanitation to minimize infection sources.
- Pre-harvest fungicide application.
- Prompt cooling after harvest.

Gray mold: Can be serious during wet spring weather.

- Avoid mechanical injuries.
- Practice good temperature management.

Rhizopus rot: Occurs in ripe or near-ripe fruits held at 68-77°F (20-25°C).

- Cool fruit and keep them below 41°F (5°C).

Bacterial spot

## Pears

### HARVEST

Quality: Buttery and juicy texture with the distinct pear aroma and taste of each pear cultivar.

### HANDLING/PACKING

Grades: Aug. 20, 1955

- **U.S. No. 1:** Of one variety, mature, but not overripe, carefully hand-picked, clean, fairly well formed, free from decay, internal breakdown, scald, freezing injury, worm holes, black end, and damage caused by hard end, bruises, broken skins, russeting, limb rubs, hail, scars, drought spot, sunburn, sprayburn, stings or other insect injury, disease, or mechanical or other means. Tolerance: 10% (5% for serious damage by insects and 1% for decay or internal breakdown).
- **U.S. Combination:** A combination of U.S. No. 1 and U.S. No. 2 may be packed. When such a combination is packed, at least 50% of the pears in any container shall meet the requirements of the U.S. No. 1 grade.
- **U.S. No. 2:** Of one variety, mature, but not overripe, carefully hand-picked, clean, not seriously misshapen, free from decay, internal breakdown, scald, freezing injury, worm holes, black end, and damage caused by hard end, or broken skins. The pears shall also be free from serious damage caused by bruises, russeting, limb rubs, hail, scars, drought spot, sunburn, sprayburn, stings or other insect injury, disease, or mechanical or other means. Tolerance: 10% (5% for serious damage by insects and 1% for decay or internal breakdown).



Cooling: Pear fruit require a period of cold storage at 30.5°F (-1°C) to induce normal ripening and to develop high dessert quality upon ripening. After a period of cold storage, they should be ripened at 68°F (20°C) in air for 4-7 days, depending upon the variety.

Washing: Washing is not necessary for pears.

Carton sizes:

**Weights:**

- 20-30 lb. box

**Sizes:** Classified by count per 20kg box

- 50, 60, 70, 80, 90, 100, 110, 120, 135, 150, 165, 180

# Pears

## **STORAGE**

- Temperature: 30.5°F (-1°C)
- Humidity: 80-85%
- Respiration: 1.25-2.5 mL/kg hr at 32°F (0°C)
- Air composition: 0.8-1% CO<sub>2</sub>, 2-2.5% O<sub>2</sub>
- Ethylene producer: Low at harvest, up to a maximum of 200 µL/kg hr when ripe. Ethylene can be used to induce ripening.
- Damage potential: Low
- Shelf life: 4-7 months, depending on cultivar

## **PESTS/DISEASES**

Various fungi: Generally result from pre-harvest fungal infections that escaped notice.

- Protect fruit from pre-harvest infections.
- Avoid damaging fruit.
- Rapid cooling after harvest.

Other postharvest diseases: Blue mold, Gray mold, Bulls-eye rot, Alternaria rot, Mucor rot, Side rot, Cladosporidium rot, Coprinus rot, Fisheye rot, Pink rot, and Rhizopus rot.

## Peas



### HARVEST

**Quality:** Uniformly bright green, fully turgid and free from defects and mechanical damage. Stems and calyxes should be green.

**Harvest tips:**

- *Don't let peas heat up after picking; if hot when picked, they should be hydro-cooled.*

### HANDLING/PACKING

**Grades – Fresh Peas:** Jun. 1, 1942

- **U.S. No. 1:** Similar varietal characteristics, not overmature or excessively small, not badly misshapen or water-soaked, and which are fairly well filled, fresh, firm, free from decay, and from damage caused by black calyxes, freezing, splitting, hail, dirt, leaves, or other foreign matter, mildew, or other diseases, insects, or mechanical or other means. The peas shall be at least fairly tender, free from decay, and from damage caused by split skins, disease, insects or mechanical or other means. Tolerance: 10% (5% for serious damage and 1% for soft decay).
- **U.S. Fancy:** Well filled and have an average of  $\frac{3}{4}$  or more by weight, of the pods in any lot, but not less than  $\frac{1}{2}$  of the pods in each container with calyxes which are of a fairly good green color, and which meet the requirements of U.S. No. 1 grade in all other respects. Tolerance: 10% (5% for serious damage and 1% for soft decay).

**Grades – Pea Pods:** Jan. 22, 2007

- **U.S. Fancy:** Similar varietal characteristics, clean, well formed, fresh, young and tender, good color, free from broken pods, decay, flabbiness, and mold, and from injury by blistering, bruising, cracks, cuts, dirt, discoloration, disease, freezing, foreign material, insects, pitted, scars, shriveling, yellowing, or mechanical or other means. Tolerance: 10% (5% for damage and 1% for decay).
- **U.S. No. 1:** Similar varietal characteristics, clean, fairly well formed, fresh, young and tender, fairly good color, free from broken pods, decay, flabbiness, and from damage by blistering, bruising, cracks, cuts, dirt, discoloration, disease, flabby, freezing, foreign material, insects, mold, pitted, scars, shriveling, yellowing, or mechanical or other means. Tolerance: 10% (5% for damage and 2% for decay).

**Cooling:** Prompt cooling after harvest reduces flavor and sugar loss.

- Forced-air cooling (preferred method for edible-podded peas)
- Hydro-cooling
- Icing

**Washing:** Vibrating washer (optional) with fresh water.

## Peas

Carton sizes:

**Weights:**

- 10 lb.  $\frac{5}{9}$  bushel cartons

**Sizes:**

- Snow peas:
  - U.S. Fancy: 2  $\frac{1}{2}$ "+
  - U.S. No. 1: 2"+
- Snap peas: 2  $\frac{1}{2}$ "-3" suggested

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-98%
- Respiration: 15-24 mL/kg hr at 32°F (0°C)
- Air composition: No extensive research. 5-7% CO<sub>2</sub> for green peas; 2-3% CO<sub>2</sub>, 2-3% O<sub>2</sub> for snow and snap peas.
- Ethylene producer: Low. Sensitive to ethylene exposure
- Damage potential: Susceptible to damage from overheating
- Shelf life: 1-2 weeks

### PESTS/DISEASES

Alternaria blight

Anthraco nose

Ascochyta Pod Spot

Powdery Mildew

Gray mold

Watery soft rot

Rhizopus rot

Bacterial soft rot

Botrytis Gray mold



## Peppers



### HARVEST

Quality: Good quality sweet bell peppers should be of uniform shape, size and color typical for the variety. The flesh (pericarp) should be firm, relatively thick with a bright skin color and sweet flavor, and be free from defects such as cracks, decay, and sunburn. Peppers that are shriveled and dull-looking or pitted should be avoided.

Harvest tips:

- *Harvest when dry.*
- *Don't field pack.*
- *Colored peppers should be at least 95% colored.*

### HANDLING/PACKING

Grades: Nov. 17, 2005

- **U.S. Fancy:** Mature green sweet peppers of similar varietal characteristics (except when more than one variety and/or color are marked on the container), that are firm, well shaped, and free from sunscald, freezing injury, decay affecting calyxes and/or walls, decay affecting stems, and free from injury caused by scars, hail, sunburn, disease, insects, mechanical or other means. Tolerance: 10% (5% for serious damage and 2% for decay).
- **U.S. No. 1:** Mature green sweet peppers of similar varietal characteristics (except when more than one variety and/or color are marked on the container), that are firm, fairly well shaped, and free from sunscald and decay affecting calyxes and/or walls, decay affecting stems, and are free from damage caused by freezing injury, hail, scars, sunburn, disease, insects, mechanical or other means. Tolerance: 10% (5% for serious damage and 2% for decay).
- **U.S. No. 2:** Mature green sweet peppers of similar varietal characteristics (except when more than one variety and/or color are marked on the container), that are firm, not seriously misshapen, and free from sunscald and decay affecting calyxes and/or walls, decay affecting stems, and are free from serious damage caused by freezing injury, hail, scars, sunburn, disease, insects, mechanical or other means. Tolerance: 10% (5% for sunscald or decay on stems and 2% for decay elsewhere).

Cooling: Rapid cooling to no lower than 45°F (7°C) postharvest.

- Forced-air
- Hydro-cooling

Washing: *Brush wash.*

# Peppers

Carton sizes:

**Weights:**

- 25 lb. 1 <sup>1</sup>/<sub>9</sub> bushel box
- 10-12 lb. <sup>5</sup>/<sub>9</sub> bushel box for colored peppers

**Sizes:**

- U.S. Fancy: 3"+ diameter, 3 <sup>1</sup>/<sub>2</sub>" + length

## **STORAGE**

- Temperature: 45°F (7°C)
- Humidity: 90-95%
- Respiration: 4-8 mL/kg hr at 50°F (10°C)
- Air composition: Not higher than 5% CO<sub>2</sub>, 2-5% O<sub>2</sub>
- Ethylene producer: 0.1 µL/kg hr. Sensitive to ethylene exposure
- Damage potential: Yes – chilling-injury below 45°F
- Shelf life: 2-3 weeks

## **PESTS/DISEASES**

Gray mold: Common on peppers.

- Use field sanitation.
- Prevent wounds.
- Dip in hot water at 126-130°F (53-55°C) for 4 min.

Alternaria black rot

- Avoid chilling-injury.

Bacterial soft rot

- Use adequate water sanitation when washing or hydro-cooling peppers.

## Perennial Herbs



### HARVEST

Quality: Herbs should appear fresh and green, with no yellowing, decay, insect damage or mechanical damage. Leaves should be uniform in size. Flavor and aroma should be strong and characteristic of the herb.

Harvest tips:

- *Harvest with a knife or scissors.*

### HANDLING/PACKING

Grades: Perennial herbs are not graded in the U.S.

Cooling: Should be cooled to just above 32°F (0°C) immediately after harvest.

Washing: Herbs should not be washed.

Materials: Herbs are bunched and tied with rubber bands or twist-ties. They are packaged in plastic bags or clamshell containers, and then packed in corrugated cartons. Perforated polyethylene liners should be used.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 90-95% (95-100% for chives)
- Respiration: 10-27 mL/kg hr at 32°F (0°C)
- Air composition: Not generally used
- Ethylene producer: Low. High sensitivity to ethylene exposure
- Damage potential: Low
- Shelf life: 1-2 weeks for marjoram, tarragon, and oregano; 2-3 weeks for most others.

### PESTS/DISEASES

Various molds and decays

- Avoid mechanical damage to herbs.
- Maintain low temperatures during storage.

## Persimmons



### HARVEST

Harvest maturity: Minimum maturity is based on skin color change from green to orange or reddish-orange (Hachiya) or to yellow or yellowish-green (Fuyu, California Fuyu, Jiro). For other varieties, fruit must have attained a yellowish-green color equal to or lighter than Munsell color chart 10Y-6/6.

Quality: Medium to large in size, with uniform skin color from yellow to orange. Fruit should be firm, i.e., penetration force (8-mm tip) >5 lb-force (22.2N) for Fuyu and similar cultivars. Fruit should be free from growth cracks, mechanical injuries and decay. SSC of 21-23% in Hachiya and 18-20% in Fuyu and similar non-astringent cultivars are recommended. Astringent cultivars must be treated to remove astringency.

Harvest tips:

- Cut fruit, rather than snap fruit from the tree by hand, leaving the calyx attached. Fruit must be handled very carefully to avoid bruising.
- 2-3 harvests are usually required to harvest the crop, depending on fruit size and color.

### HANDLING/PACKING

Grades: Persimmons are not graded in the U.S.

Cooling:<sup>15</sup>

- Forced-air cooling

Size (Fuyu variety): 8.1-8.8 oz. (230-250g). 7.1 oz. (200g) is the minimum saleable size.

### STORAGE

- Temperature: 32-34°F (0-1°C).
- Humidity: 90- 95%
- Respiration: 2-4 mL/kg hr at 32°F (0°C)
- Air composition: Low O<sub>2</sub> atmospheres of 3-5% delays ripening. CO<sub>2</sub> at 5-8% helps retain firmness and can reduce chilling-injury symptoms in Fuyu and similar cultivars.
- Ethylene producer: Low. Very sensitive to ethylene. Ethylene removal and/or exclusion from transport and storage facilities is recommended.
- Damage potential: Sensitivity varies. Hachiya is not chilling-sensitive while Fuyu and similar non-astringent cultivars will exhibit flesh browning/softening between 41-59°F (5-15°C). Exposure to ethylene aggravates chilling-injury at these temperatures.
- Shelf life: 3 months (under optimum temperature and RH conditions in ethylene-free air) and 5 months using ethylene-free conditions with 3-5% O<sub>2</sub> and 5-8% CO<sub>2</sub>.

### PESTS/DISEASES

Alternaria rot (*Alternaria alternata*): Infection remains dormant until after harvest, when black spots become apparent during ripening. Wound infection results in earlier appearance of symptoms.

Other decay mechanisms: Include species of *Botrytis*, *Cladosporium*, *Colletotrichum*, *Mucor*, *Penicillium*, *Phoma*, and *Rhizopus*.

## Pineapples



### HARVEST

**Harvest maturity:** Evaluated based on fruit “eye” flatness and skin yellowing. Consumers judge fruit quality by skin color and aroma. Fruit do not continue to ripen or sweeten after harvest. Fully-ripe, yellow fruit are unsuitable for transporting to distant markets, so slightly less mature fruit are required for this purpose. Immature fruit should not be shipped since they do not develop good flavor, have low brix and are more prone to chilling-injury.

**Quality:** Must have a desirable size and shape, with flat “eyes” and deep green crown leaves that look fresh. High shell color is not always a good measure of sweetness. Negative characteristics include: dry, brown crown leaves, dull, yellow skin appearance, presence of mold on the surface or cut stem and fruit having an unfirm feel.

**Harvest tips:**

- Ease of removal of crown leaves, full skin yellowing or the sound produced by tapping fruit are not signs of ripeness or quality. Fruit are picked at the ripe stage and are ready-to-eat, even if there is a little skin yellowing.
- Crowns developed during summer in Hawaii tend to be larger than standard requirements and may require gouging (removal of the crown center) at harvest.

### HANDLING/PACKING

**Grades:** May 02, 2008

- **U.S. Fancy:** (For fruit) Similar varietal characteristics, with stems removed, and free from fresh cracks, evidence of rodent feeding, frozen or freezing injury, being overripe and decay. Fruit shall be free from injury by bruising, sunburn, gummosis, internal breakdown, insects, healed cracks and mechanical or other means. (For tops) Similar varietal characteristic color, single stem, moderately straight, well attached to fruit, and not more than 1 1/2 times the length of the fruit, and free from crown slips, frozen or freezing injury, and decay. Tops shall be free from injury by discoloration and insects. Tolerances: Defects at shipping point: 8% for grade requirements (4% for defects causing serious damage and 1% for decay). Defects en route or at destination: 12% (8% for permanent defects, 6% for serious damage including 4% for serious damage by permanent defects and 2% for decay).
- **U.S. No. 1:** (For fruit) Same as U.S. Fancy, except fruit shall be free from damage from the injury mechanisms outlined in the U.S. Fancy grade. (For tops) Same as U.S. Fancy, except may be not more than moderately curved and not more than twice the length of the fruit. Tops shall be free from damage by discoloration, crown slip, and insects. Tolerances: As for U.S. Fancy grade.
- **U.S. No. 2:** (For fruit) Same as U.S. Fancy grade except may be fairly well formed where fruit is not excessively lopsided or excessively flattened at the shoulders or sides. Fruit shall be free from serious damage from the injury mechanisms outlined in the Fancy grade. (For tops) Same as U.S. Fancy grade but shall be not completely curved over and have not more than two fairly well developed stems. Tops shall be free from serious damage by discoloration and insects. Tolerances: Defects at shipping point: 8% (1% for decay). Defects en route or at destination: 12% (8% for permanent defects and 2% for decay).

**Cooling:**

- Room cooling
- Forced-air cooling

**Washing:**<sup>16</sup> May be washed in sanitized water if necessary

## Pineapples

**Carton sizes:** Generally two different sizes used on the basis of color and size: a large telescoping fiberboard carton holding 40-lb. (18kg) and containing 8-10 fruit in two layers for surface and air shipment, and a smaller container of 20-lb. (9kg) with 5-6 fruit in a single layer laid flat for air shipment. Tourist packs of 2-4 fruit are also prepared. Absorbent pads are used at the bottom of the carton and between layers.

**Sizes** (All grades): Weight of the fruit within individual containers shall not vary more than 1 1/2 pounds from smallest to largest and not more than 5% of the packages in any lot may fail to meet the requirements pertaining to size and marking.

- Ratio of crown:fruit length is 1/3-1 1/2 for higher grades

### STORAGE

- Temperature: 45-5 °F (7-12°C) at color break stage, 45°F (7.2°C) for ripe fruit.
- Humidity: 85-95%
- Respiration: 1 mL/kg hr at 41°F (5°C)
- Air Composition: Tentative recommendation is 2-5%O<sub>2</sub> and 5-10% CO<sub>2</sub>. Low O<sub>2</sub> has no effect on crown condition or decay, but does delay shell color development and reduce superficial mold growth. 4% O<sub>2</sub> can reduce chilling-injury development.
- Ethylene producer: Low. Degreening possible but chemical not approved for use in the U.S.
- Damage potential: Chilling-injury causes wilting, drying, and discoloration of crown leaves, failure of green-shelled fruit to yellow, browning and dulling of yellow fruit, and internal flesh browning. Pre-harvest shading and preharvest and postharvest low temperatures can increase symptom intensity. Susceptible fruit are generally lower in ascorbate and sugar content and are opaque. Fruit waxing can delay appearance of chilling-induced internal browning.
- Shelf life: 14-20 days for fruit at color break stage, 7-10 days for ripe fruit

### PESTS/DISEASES

**Black rot** (*Thielaviopsis* fruit rot, water blister, soft rot, or water rot): Characterized by a soft watery rot. Diseased tissue turns dark in later stages of the disease. Red Spanish types are more resistant than the Smooth Cayenne variety. Infection occurs within 8-12 hr following harvest, and enters through the point of detachment or wounds.

- Minimize bruising of fruit during harvest and handling.
- Refrigerate at recommended temperature and humidity.
- Use postharvest fungicides.

**Various Fungi** (often referred to as fruitlet core rot, black spot, fruitlet brown rot and eye rot): Cause brown to black color of the central part of an individual fruitlet. Low-acid cultivars are most susceptible. Infection can frequently lead to misshapen fruit that are culled before packing.

**Yeasty fermentation:** Pineapple fruit contain many non-growing but viable yeasts and bacteria. In damaged, overripe fruit, resident yeasts begin to grow, or new yeasts invade. This leads to fermentation causing the skin to turn brown and leathery, and the fruit to become spongy with bright yellow flesh.

**Saprophytes** (*Penicillium* sp.): Grow on the broken end of the peduncle and fruit surface. Non-pathogenic but are unsightly. More common in highly translucent fruit.

## Plums



### HARVEST

Quality: High consumer acceptance for fruit with high SSC. Fruit TA, SSC:TA and phenolic content (astringency) are also important factors in consumer acceptance. However, there is no established minimum quality standard based on these factors. Plums with about 10N (1 kg-force) flesh firmness (8-mm tip) are considered ready-to-eat.

### HANDLING/PACKING

Grades: Mar. 29, 2004

- **U.S. Fancy:** Plums or prunes of one variety that are well formed, clean, mature but not overripe or soft or shriveled, that are free from decay, sunscald, heat injury, sunburn, split pits and hail marks, and from damage caused by broken skins, growth cracks, drought spots, gum spots, russeting, scars, other disease, insects, or mechanical or other means. Tolerance: 8% (4% for serious damage and 0.5% for decay).
- **U.S. No. 1:** Plums or prunes of one variety that are well formed, clean, mature but not overripe or soft or shriveled, that are free from decay and sunscald, and from damage caused by broken skins, heat injury, growth cracks, sunburn, split pits, hail marks, drought spots, gum spots, russeting, scars, other disease, insects, or mechanical or other means. Tolerance: 8% (4% for serious damage and 0.5% for decay).
- **U.S. Combination:** A combination of U.S. No. 1 and U.S. No. 2 plums or prunes, provided that at least 75%, by count, meet the requirements of the U.S. No. 1 grade.
- **U.S. No. 2:** Plums or prunes of one variety that are not badly misshapen, that are clean, mature but not overripe or soft or shriveled, that are free from decay and sunscald, and from serious damage caused by broken skins, heat injury, growth cracks, sunburn, split pits, hail marks, drought spots, gum spots, russeting, scars, other disease, insects or mechanical or other means. Tolerance: 8% (4% for serious damage by insects or heat injury and 0.5% for decay).

### Cooling:

- Forced-air cooling
- Hydro-cooling
- Room cooling

Washing: May be washed in sanitized water.

# Plums

Carton sizes:

**Weights:**

- 28-lb. volume-filled containers
- ½ bu. box

**Sizes:**

- Minimum diameter: 1.25" for U.S. Fancy and U.S. No. 1

Materials: Fruit are hand-picked into bags.

## **STORAGE**

- Temperature: *around 32°F (0°C)*
- Humidity: *80-85%*
- Respiration: *1-1.5 mL/kg hr at 32°F (0°C)*
- Air composition: *3-5% CO<sub>2</sub>, 1-2% O<sub>2</sub>*
- Ethylene producer: *0.01-5.0 µL/kg hr; slow-ripening cultivars may need an application of 100 µL/L for 24 hours at 68°F (20°C).*
- Damage potential: *Chilling-injury*
- Shelf life: *Up to 2 months depending on variety*

## **PESTS/DISEASES**

Brown rot: The most important postharvest disease of stone fruits.

- Sanitize orchard to minimize infection sources.
- Cool promptly after harvest.

Gray mold: Can be serious during wet spring weather.

- Avoid mechanical injuries.
- Practice good temperature management.

Rhizopus rot: Occurs in ripe or near-ripe fruits held at 68-77°F (20-25°C).

- Cool fruit and keep them below 41°F (5°C).



## Pomegranates



### HARVEST

Harvest maturity: Do not ripen after harvest and must be picked fully-ripe to ensure the best eating quality. Size, skin color, TA and SSC are used as maturity indices, with each pomegranate type requiring a certain TA:SSC at harvest. TA varies between 0.13- 4.98% and SSC varies from 8.3-20.5%. The TA is <1% in sweet cultivars, 1-2% in sweet-sour cultivars and >2% in sour cultivars. Juice tannin content <0.25% is preferred and red juice color equal to or darker than Munsel color chart 5R-5/12 is desirable.

Quality: Depends largely on the sugar and acid content of the juice. Should also have an attractive skin color and smoothness, small seeds in the aril and should be free from sunburn, growth cracks, cuts, bruises and decay. Sour and sour-sweet pomegranates have reddish skin, in contrast to sweet pomegranates, which have yellowish-green skin.

### HANDLING/PACKING

Grades: Pomegranates are not graded in the U.S.

Cooling: Not applicable.

Washing: Can be dry brushed if necessary or washed in sanitized water

Carton sizes: Generally packed into 2-layer tray packs or bulk cartons.

**Sizes** (based on Turkish standard):

- Small: 150-200g, 65-74mm diameter, 25-34 fruit/5kg carton
- Medium: 201-300g, 75-84mm diameter, 17-25 fruit/5kg carton
- Large: 301-400g, 85-94mm diameter, 13-17 fruit/5kg carton
- Extra Large: 401-500g, 94-104mm diameter, 10-13 fruit/5kg carton

Materials: Waxing fruit and storage in plastic liners can reduce weight loss.

## Pomegranates

### STORAGE

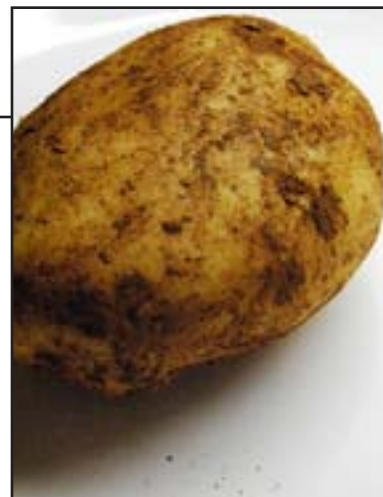
- Temperature: 42.8°F (6°C) for Hicaznar variety (with 90% RH). Optimum storage temperature varies for cultivar, production area and postharvest treatment.
- Humidity: 90-98%. Skin desiccates readily at low humidity resulting in hard, darkened rinds which are unattractive and have reduced marketability.
- Respiration: 2.1-4.2 mL/kg hr at 41°F (5°C)
- Air composition: 3% O<sub>2</sub> and 6% CO<sub>2</sub>. Reduces loss of TA and vitamin C
- Ethylene producer: Very low. Not particularly sensitive to ethylene exposure.
- Damage potential: Susceptible to chilling-injury and should not be stored <41°F (5°C). External symptoms include rind pitting, brown discoloration of skin and increased susceptibility to decay. Internal symptoms include a pale aril color and brown discoloration of the white segments separating the arils.
- Shelf life: 6 months for Hicaznar variety at 42.8°F (6°C) under CA conditions.

### PESTS/DISEASES

Various Molds: Gray mold (*Botrytis cinerea*) usually starts at the calyx. As it progresses, the skin becomes light-brown, tough and leathery. Green mold (*Penicillium digitatum*) rot and *Cladosporium spp.* are other postharvest diseases affecting fruit.

Heart rot: May be caused by *Aspergillus spp.* and *Alternaria spp.* Leads to slightly abnormal skin color and a mass of blackened arils. Develops while fruit are still on the tree.

## Potatoes



### HARVEST

**Quality:** A high quality fresh-market potato tuber will be turgid, well shaped, uniform, brightly colored (especially reds, whites and yellows), as well as free from adhering soil, mechanical damage, greening, sprouts, diseases, and physiological defects.

**Harvest tips:**

- *New potatoes have thin skins. Extra care should be taken when harvesting and washing to not damage the skin. May need to be hand-dug and gently washed.*

### HANDLING/PACKING

**Grades:** Nov. 21, 2008

- **U.S. No. 1:** Similar varietal characteristics, firm, fairly clean, and fairly well shaped. Free from freezing damage, blackheart, late blight, southern bacterial wilt, ring rot, soft rot, and wet breakdown. Free from damage by any other cause. Should be Size A. Tolerance: (Defects): At shipping point: 8% (5% for external defects, 5% for internal defects, and 1% for frozen, soft rot or wet breakdown). Defects en route or at destination: 10% (7% for external defects, 7% for internal defects, and 2% for frozen, soft rot or wet breakdown). (Off-size): Not more than 3% in any lot may be smaller than the required or specified minimum size except that a tolerance of 5% shall be allowed for potatoes packed to meet a minimum size of 2 1/4" in diameter or 5-oz. or more in weight. Not more than 10% may be larger than any required or specified maximum size. When specified to be of a certain size and larger, individual samples shall have not less than 1/2 of the percentage specified, provided, that the average for the entire lot is not less than the percentage specified.
- **U.S. Commercial:** Same as U.S. No. 1, except shall be free from serious damage caused by dirt or other foreign matter, russet scab, and rhizoctonia. Tolerance (Defects): 20% (10% for potatoes not meeting U.S. No. 2 standards, 6% for external defects, 6% for internal defects, 1% for frozen, soft rot or wet breakdown). (Off-size): As for U.S. No. 1.
- **U.S. No. 2:** Similar varietal characteristics and not seriously misshapen. Free from freezing, blackheart, late blight, southern bacterial wilt, ring rot, soft rot, and wet breakdown. Free from serious damage by any other cause. Should not be less than 1.5" in diameter. Tolerance: (Defects): At shipping point: 10% (6% for external defects, 6% for internal defects, 1% for frozen, soft rot or wet breakdown). En route or at destination: 12% (8% for external defects, 8% for internal defects, and 2% for frozen, soft rot or wet breakdown). (Off-size): As for U.S. No. 1.
- **Unclassified**

**Cooling:** Potatoes which are to be kept in long-term storage should be cured for 1-2 weeks at 68°F (20°C), (or 59°F [15°C] to minimize decay) with a RH of 80-100%. After curing, temperature should be lowered by 1-2°C each day until storage temperature is reached.

**Washing:** *Hand wash, or brush wash if skins are tough enough.*

# Potatoes

Carton sizes:

**Weights:**

- Bulk 50-lb 1 <sup>1</sup>/<sub>9</sub> bu. carton
- Bulk 25-lb <sup>5</sup>/<sub>9</sub> bu. carton
- “Count” 50-lb. boxes
- 5-or 10-lb. plastic or paper bags
- 2-lb. net bags B-sized tubers

**Sizes:** (Diameters)

- Size A: 1 <sup>7</sup>/<sub>8</sub>”+
- Size B: 1 <sup>1</sup>/<sub>2</sub> - 2 <sup>1</sup>/<sub>4</sub>”
- Small: 1 <sup>3</sup>/<sub>4</sub> - 2 <sup>1</sup>/<sub>2</sub>”
- Medium: 2 <sup>1</sup>/<sub>4</sub> - 3 <sup>1</sup>/<sub>4</sub>”
- Large: 3 - 4 <sup>1</sup>/<sub>4</sub>”

**STORAGE**

- Temperature: 45-50°F (7-10°C)
- Humidity: 95-99%
- Respiration: 7-10 mL/kg hr at 50°F (10°C)
- Air composition: Minimal usefulness
- Ethylene producer: Very low. Not sensitive to ethylene exposure
- Damage potential: *Chilling-sensitive; store potatoes in the dark as they are sensitive to light.*
- Shelf life: 2-12 months

**PESTS/DISEASES**

Many bacterial and fungal pathogens

- Carefully sort potatoes before putting into storage.
- Manage RH and temperature during storage.

## Prickly Pear



### HARVEST

Harvest maturity: Peel color is the single most important index for commercial harvest but other indices include fruit size and fullness, abscission of the small spines, firmness and flattening of the floral cavity.

Quality: Fruit need to be harvested near full-ripe to have color and flavor typical of each variety since sugar content and sweetness does not increase after harvest. Should have a high percentage of pulp, low content of seeds and have peel that is easy to remove. Fruit typically have high sugar content (12-17% SSC) and low acidity (0.03-0.12% TA). Good quality fruit have a delicate sweet flavor that differs with variety.

#### Harvest tips:

- Fruit can bruise easily by finger compression during harvest. Damage to the stem-end is more serious and can be eliminated by twisting fruit from the stem or cutting fruit with a small piece of stem attached.
- Fruit with stem may be packed that way or cured under moderate temperatures of 59-68°F (15-20°C) with airflow so the stem dries and falls off before packing. This prevents damage to the stem-end and greatly reduces decay incidence.
- High-gloss fruit waxes improve visual appearance and reduce dehydration. Especially important if fruit are dry-brushed to remove small tufts of spines.

### HANDLING/PACKING

Grades: Prickly pears are not graded in the U.S.

Cooling: Cool to 41°F (5°C) to reduce dulling of fruit surface due to water loss. Cooling may be delayed if fruit undergo a curing treatment.

- Room cooling
- Forced-air cooling

Washing: May be washed in hot water to reduce decay and to remove spines.

Carton sizes: Packed according to color, size and condition in 10-lb. (4 1/2 kg) cartons, or may be packed in single or double layer tray cartons.

Materials: Large fruit may be wrapped in tissue paper to reduce scuffing and other physical injury. Fruit may also be packaged in cartons with perforated plastic liners to reduce water loss under dry storage conditions.

# Prickly Pear

## STORAGE

- Temperature: 41-46°F (5-8°C)
- Humidity: 90-95%
- Respiration: Low. 15-20  $\mu\text{l CO}_2$  / kg hr at 68°F (20°C)
- Air composition: 2% O<sub>2</sub> and 2-5% CO<sub>2</sub>
- Ethylene producer: Very low. Not sensitive to ethylene exposure
- Damage potential: Especially chilling-sensitive when stored <41°F (5°C), but chilling-injury may occur in some varieties <50°F (10°C). Symptoms include pitting, surface bronzing and dark spots on the peel and increased susceptibility to decay. Summer harvested fruit are more chilling-sensitive than fall harvested fruit. Application of calcium chloride, conditioning and intermittent warming have had variable success in reducing injury.
- Shelf life: 2-5 weeks depending on variety, ripeness stage and harvest season

## PESTS/DISEASES

Various decay mechanisms: Fungi including *Fusarium spp.*, *Alternaria spp* and *Penicillium spp*. Yeasts and bacteria also cause decay.

- Minimize damage to the peel and stem-end of cactus fruit.
- 5 min hot water dips at 127-131°F (53-55°C) and fungicide-containing waxes may reduce surface decay. Not effective when there is damage to stem-ends.
- Use pre-harvest calcium sprays.

# Pumpkins/ Jack-o-Lanterns



## HARVEST

Quality: Fully mature, with hard rinds and, except for some striped varieties, solid external color. Flesh of good quality pumpkins and winter squash is bright yellow or orange with fine, moist texture and high solids, sugars, and starch.

Harvest tips:

- *Clip leaving long stems if selling for decoration.*
- *Place in bins with caution so as not to break stems.*
- *Ensure proper ventilation to increase storage life.*
- *Avoid puncturing flesh.*

## HANDLING/PACKING

Grades: Oct. 13, 1983

- **U.S. No. 1:** Similar varietal characteristics, well matured, and not broken or cracked. Free from soft rot or wet breakdown. Free from damage by scars, dry rot, freezing, dirt, disease, insects, and mechanical or other means. Tolerance: 10% (2% for soft rot or wet breakdown or serious damage by dry rot).
- **U.S. No. 2:** Similar varietal characteristics, fairly well matured, and not broken or cracked. Free from soft rot or wet breakdown. Free from serious damage by scars, dry rot, freezing, dirt, disease, insects, and mechanical or other means. Tolerance: 10% (2% for soft rot or wet breakdown or serious damage by dry rot).

Cooling: *No cooling necessary.*

Washing: *Rub dirt off in field with a burlap cloth*

Carton sizes:

**Weights:**

- 800-900 lb. bulk containers

## STORAGE

- Temperature: 50-55°F (10-13°C)
- Humidity: 50-70%
- Air composition: Unknown
- Ethylene producer: Very low. Somewhat sensitive to ethylene exposure
- Damage potential: Moderately chilling sensitive
- Shelf life: 2-3 months

## PESTS/DISEASES

Various decay agents:

- Avoid chilling-injury.
- Avoid wounding pumpkin flesh.
- Dip in hot water at 140°F (60°C) for 2 min.

## Quince



### HARVEST

Quality: Freedom from insect damage, mechanical damage, and decay. Harvest begins when fruit change their ground color from deep-green to a lighter-green. Green, immature fruit scalds readily in storage and fruit affected with scab does not store well.

### HANDLING/PACKING

Grades: Quince is not graded in the U.S.

Washing: Dry brush gently to remove fuzz.

Materials: Shipping barrel or box should be lined with soft pads at both ends. The blossom end should be turned upward rather than the stem-end. Fruit should be handled carefully to avoid bruising.

### STORAGE

- Temperature: 31-32°F (-0.5-0°C)
- Humidity: 90%
- Air composition: No recommendations
- Ethylene producer: Ethylene production accelerates with ripening; exact figures are not available.
- Damage potential: Very susceptible to bruising
- Shelf life: 2-3 months

### PESTS/DISEASES

Similar to apples and pears.



## Radichio



### HARVEST

Quality: Plants and leaves should be very turgid and crisp, with bright white midribs. There should be no cracking, splitting, dark spots due to mechanical damage or necrosis on the root. The root must be cleanly cut with no secondary roots or evidence of decay, and cannot exceed 1 1/2". (4cm).

Harvest tips:

- Harvest early or when cool. Wetness is okay.
- Use a field knife to harvest.
- Harvest into a container holding 24 heads.
- Damaged or yellow leaves should be removed.
- Cut above ground to keep knife clean and remove only the good portion – a good picker will not have to retrim.
- Wipe field knife on pants between each cut.
- Be careful not to handle roughly.
- Cut open several heads to make sure there is no tip burn (brown on edges of internal leaves).

### HANDLING/PACKING

Grades: Radichio is not graded in the U.S.

Cooling: Radichio is usually placed directly in a cold room before shipping.

Washing: Wash in sanitized water. Drain upside-down.

Materials: Packing can be in trays with shrinkable plastic film or in corrugated containers with plastic liners to avoid water loss.

### STORAGE

- Temperature: 37-41°F (3-5°C)
- Humidity: 90%
- Respiration: 3-5 mL/kg hr at 32°F (0°C)
- Air composition: 5% CO<sub>2</sub>, 3% O<sub>2</sub>
- Ethylene producer: Very low. Sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 20-30 days

### PESTS/DISEASES

Bacterial soft rot

*Pectolytic Pseudomonas*

*Botrytis cinerea*

## Radishes



### HARVEST

Harvest maturity: Based on size and market demand. The diameter of oval types should be between 0.75-1.25" (2-3 cm). Bunched radishes are harvested in either regular or big bunch size and roots for cello packages are pulled at regular or jumbo sizes.

Quality: Roots shall be fresh, well-colored, tender, firm, crisp and not be stringy or woody, soft, flabby or wilted. Bunched radishes should have fully intact tops that are dark-green with no yellowing.

### HANDLING/PACKING

Grades: Oct. 01, 1968

- **U.S. No. 1:** Similar varietal characteristics, with roots that are clean, well formed, smooth, firm, where the root is crisp and not soft, flabby or wilted. Shall be tender, free from decay and free from damage caused by freezing, growth or air cracks, cuts, pithiness, disease, insects, or other means. Bunched radishes have tops which are fresh with normal green color and not more than slightly wilted. Shall be free from decay and free from damage caused by freezing, seedstems, yellowing or other discoloration, disease, insects or other means. Unless otherwise specified, the diameter of each root shall be not less than  $\frac{5}{8}$ ". Tolerances (Defects): Roots: 10% (1% for decay). For tops of bunched radishes: 10% (5% for decay). For off-size roots: 10% for roots which fail to meet the specified minimum diameter, provided that when both minimum and maximum diameters are specified, an additional tolerance of 10% shall be allowed for roots which are larger than the maximum diameter specified. For excess length of tops of topped radishes: 5% for tops more than  $\frac{3}{8}$ " long.
- **U.S. Commercial:** Same as for U.S. No. 1 except for increased tolerances. Tolerances (Defects): Roots: 20% fail to meet the grade requirements (10% for serious damage and 1% for decay). For tops of bunched radishes: 10% (5% for decay). For off-size roots: 10% for roots which fail to meet the specified minimum diameter, provided that when both minimum and maximum diameters are specified, an additional tolerance of 10% shall be allowed for roots which are larger than the maximum diameter specified. For excess length of tops of topped radishes: 10% for tops more than  $\frac{3}{8}$ " long.

Cooling: Hydro-cooling

Washing: Dip in chlorinated water at 26°F (2.2°C) to restore crispness and freshness to tops and roots, as well as to remove field debris.

Carton sizes: Topped radishes are packed in 6-oz. (168g), 8-oz. (224g), 1-lb. (454g), 5-lb. (2.3kg), 25-lb. (11kg) and 40-lb. (1 kg) perforated plastic bags. Commonly, thirty 6-oz., twenty-four 8-oz. or fourteen 1-lb. bags are boxed together for retail, while 25-lb. (11kg) bags are used for the foodservice industry. Standard bunches of radishes shall be fairly uniform in size and radishes in the individual bunches shall not vary more than  $\frac{1}{2}$ " in diameter. Not more than 10% of the bunches in any lot may fail to meet the requirements for standard bunching.

## Radishes

### Sizes:

- Small:  $< \frac{3}{4}$ " in diameter
- Medium:  $\frac{3}{4}$  - 1" in diameter
- Large:  $> 1$  -  $1 \frac{1}{4}$ " in diameter
- Very large/jumbo:  $> 1 \frac{1}{4}$ " in diameter

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 90-95%
- Respiration: Topped Roots: 7-8.5 mL/kg hr at 32°F (0°C). Bunched Roots with Tops: 1.5-4.5 mL/kg hr at 32°F (0°C)
- Air Composition: 1 to 2% O<sub>2</sub> and 2-3% CO<sub>2</sub>
- Ethylene producer: Low. Not particularly sensitive to ethylene exposure
- Damage potential: Not chilling-sensitive and should be stored as cold as possible without freezing. Freezing injury causes softening, shriveling and leakage of pigment for red radishes.
- Shelf life: 3-4 weeks for topped radishes. 1-2 weeks for bunch radishes (addition of top ice may help keep tops fresh). 2-4 months for winter or black radishes.

### PESTS/DISEASES

Black spot (*Xanthomonas vesicatoria*): Brown lesions which turn black and coalesce.

- Wash in water with 100-200 ppm of chlorine.

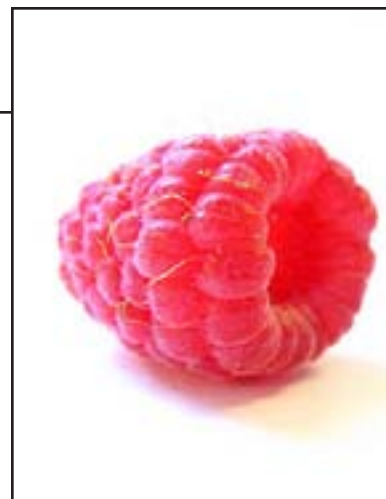
Downy mildew (*Peronospora parasitica*): Produces purplish-red to brown surface lesions that become rough and cracked. Internal tissue can become grayish brown to black.

- Avoid bruising.
- Hydro-cool to 40°F (4.4°C) and store at recommend temperature.

Rhizoctonia root rot (*Rhizoctonia solani*): Produces lesions that are initially round and light brown that become slightly sunken. Tissue can become spongy. Favors high RH.

- As for Downy mildew.

# Raspberries



## HARVEST

Quality: Free of injury, decay, and sunscald, are uniformly colored, and appear turgid. Berries should pull or shake easily from the receptacle, yet be firm and not mushy.

## HANDLING/PACKING

Grades: May 29, 1931

- **U.S. No. 1:** Of one variety, well colored, well developed and not soft, overripe, or broken, that are free from cores, sunscald, mold, and decay, and from damage caused by dirt or other foreign matter, shriveling, moisture, disease, insects, or mechanical or other means. Tolerance: 10% (5% for serious damage and 1% for mold or decay).
- **U.S. No. 2:** Same as U.S. No. 1, except for tolerances. Tolerance: 10% for serious damage, 2% for mold or decay.
- **Unclassified**

Cooling: Raspberries should be forced-air cooled to 34°F (1°C) as soon as possible after harvest.

Washing: Raspberries should not be washed.

Carton sizes:

### Weights:

- Trays holding 12 *pint* or half pint containers

Materials: Vented clamshell containers are standard.

## STORAGE

- Temperature: *around 32 °F (0°C)*
- Humidity: <90%
- Respiration: 8-9 mL/kg hr at 32°F (0°C)
- Air composition: 10-20% CO<sub>2</sub>, 5-10% O<sub>2</sub>
- Ethylene producer: 1-12 µL/kg hr. Color and mold growth can be affected by ethylene exposure.
- Damage potential: Low
- Shelf life: *2-5 days under ideal conditions*

## PESTS/DISEASES

Gray mold

Rhizopus rot

Brown rot

## Rhubarb



### HARVEST

Quality: Petiole color is associated with rhubarb quality. Color in order of preference is red, pink, and green. Whether presented for sale intact or cut into sections, petioles should appear fresh with no signs of desiccation or decay.

### HANDLING/PACKING

Grades: Feb. 1, 1966

- **U.S. Fancy:** Similar varietal characteristics, very well colored, fresh, tender, straight, clean, well trimmed and not pithy, free from decay and from damage caused by scars, freezing, disease, insects, or mechanical or other means. Tolerance: 10% (1% for decay).
- **U.S. No. 1:** Similar varietal characteristics, well colored, fresh, tender, straight, clean, well trimmed and not pithy, free from decay and from damage caused by scars, freezing, disease, insects, or mechanical or other means. Tolerance: 10% (1% for decay).
- **U.S. No. 2:** Similar varietal characteristics which are fairly well colored, fresh, fairly straight, clean, well trimmed and not pithy, which are free from decay, and free from serious damage caused by scars, freezing, disease, insects or mechanical or other means. Tolerance: 10% (1% for decay).
- **Unclassified**

Cooling: Rhubarb petioles should be pre-cooled to 32°F (0°C)

- Forced-air cooling
- Hydro-cooling

Washing: Wash in chlorinated water.

Carton sizes:

**Weights:**

- 10-, 15-, or 20-lb. cartons

**Sizes:**

- U.S. Fancy: 1"+ diameter; 10"+ length
- U.S. No. 1: ¾"+ diameter; 10"+ length
- U.S. No. 2: ½"+ diameter; 8"+ length

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-100%
- Respiration: 4.5-6.5 mL/kg hr at 32°F (0°C)
- Air composition: Not generally used
- Damage potential: Low
- Shelf life: 2-4 weeks

### PESTS/DISEASES

Various decay agents: Anthracnose, bacterial soft rot, and gray mold.

- Use proper sanitation for hydro-cooling water.
- Maintain recommended storage temperature.

## Rutabaga



### HARVEST

Quality: Well-shaped, purple-top root that has a smooth, small neck, and a well-defined taproot with a minimum of side roots. Shall be free of blemishes and bruises. The roots should be firm, fresh looking, sweet and not bitter, and heavy for their size. Lightweight rutabagas may be woody.

Harvest tips:

- Use a bed lifter or pull by hand.

### HANDLING/PACKING

Grades: Aug. 1, 1955

- **U.S. No. 1:** Similar varietal characteristics, roots that are well trimmed, firm, fairly smooth, fairly well shaped, fairly clean, and free from soft rot and damage caused by cuts, discoloration, freezing, growth cracks, pithiness, woodiness, watercore, dry rot, other disease, insects or rodents, or mechanical or other means. Diameter shall not be less than 1  $\frac{3}{4}$ ". Tolerance: 10% (5% for serious defects and 1% for soft rot).
- **U.S. No. 2:** Similar varietal characteristics, roots that are well trimmed, firm, not excessively rough, not seriously misshapen and which are free from soft rot and serious damage caused by cuts, dirt, discoloration, freezing, growth cracks, pithiness, woodiness, watercore, dry rot, disease, insects or rodents, or mechanical or other means. Diameter shall not be less than 1  $\frac{3}{4}$ ". Tolerance: 10% (5% for serious defects and 1% for soft rot).

Cooling: If harvested when the soil or air is above 77°F (25°C), they should be cooled within 3-4 hr. to avoid loss of quality during storage.

- Forced-air cooling

Washing: *Barrel-wash. Wash after storage.*

Carton sizes:

#### Weights:

- 25-lb.  $\frac{5}{9}$  bushel cartons with perforated polyethylene liners

#### Sizes:

- Small: 2"-4"
- Small-Medium: 3  $\frac{1}{2}$ - 5  $\frac{1}{2}$ "
- Medium: 4"-6"
- Large: 5"-7"

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 98-100%
- Respiration: 2-3 mL/kg hr at 32°F (0°C)
- Air composition: Not commonly used
- Ethylene producer: Very low. Not sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 4-6 months

### PESTS/DISEASES

Various rots: Brown rot, black rot, and bacterial soft rot.

- Store at recommended temperatures.

Phoma lesions: Occur on cut surfaces and as small craters on undamaged skin.

## Salad Greens



### HARVEST

Quality: Fresh, tender and turgid, with no yellowing, decay, or insect or mechanical damage. Whole plants of rocket and lamb's lettuce are sometimes sold with roots attached, which lengthens postharvest life.

Harvest tips:

- *Harvest in the morning or the cool part of the day. It's okay if the greens are still wet – in fact this is desirable.*
- *Use a field knife, scissors, or a mechanical salad cutter.*
- *Should be kept in the shade if not cooled immediately. Should be cooled within 1-2 hours. Having a refrigerated truck in the field, or a tank of cold water can help on hot days.*

### HANDLING/PACKING

Grades: Salad greens are not graded in the U.S.

Cooling: Greens for salads should be cooled to 32°F (0°C) as soon as possible after harvest.

Washing: *Salad washer - double wash and spin dry. First washing should have sanitizer.*

Materials: Salad greens may be packed in fiberboard cartons lined with perforated polyethylene bags, 6-oz. sealed plastic bags, trays or clamshell containers.

### STORAGE

- Temperature: 32-36°F (0-2°C)
- Humidity: 95-100%
- Respiration: 6-21 mL/kg hr at 32°F (0°C)
- Air composition: Generally not beneficial
- Ethylene producer: Low. Very sensitive to ethylene exposure
- Damage potential: *Extremely high – must be maintained at consistent cold temperatures*
- Shelf life: 7-14 days

### PESTS/DISEASES

Bacterial soft rot and fungal decay: Similar to that of lettuce.

- Maintain low temperatures.

## Southern Peas



### HARVEST

**Harvest maturity:** Pea color is affected both by maturity and cultivar. Harvest for fresh market when pods are at mature-green stage (peas are fully developed when the majority of the pods have undergone a color change). It is acceptable to have some pods that have not undergone a complete color change (green with some purpling in the case of purple hulls) provided the peas are of mature size. Shelled peas should be light green in color. Tan or white pea color is perceived to be too mature (except for cream types).

Blackeye cultivars are difficult to determine when to harvest because the color of the black hilum does not fully develop until peak maturity. The color will be purple to chocolate-brown if harvested early. If southern peas are harvested for edible pod use, they must be quite young and tender, i.e., no more than  $\frac{1}{2}$  of the expected diameter of mature green pods, unless using a cultivar specifically developed for edible pod use.

**Quality:** Those with edible pods should be harvested when pods are 4-6" (10-16cm) long, flexible and dark green.

**Harvest tips:**

- Failure to pre-cool shelled peas prior to packaging results in condensation in the bags and rapid souring and spoiling.

### HANDLING/PACKING

**Grades:** July 13, 1956

- **U.S. No. 1:** Similar varietal characteristics, are fairly well formed, fairly well filled, and not overmature or excessively young. Shall be free from decay, worm holes and damage caused by stems, leaves and trash, stings or other insect injury, scars, discoloration, wilting, dirt or other adhering foreign material, disease and from mechanical or other means. Each pod shall be not less than 5" in length. Tolerances: 5% for pods shorter than the minimum length, 5% for excessively young pods, 10% for other grade defects (5% for pods with worm holes or affected by decay and 1% for decay).
- **U.S. Commercial:** Shall meet the requirements of U.S. No. 1 grade, except that peas shall be free from serious damage caused by stems, leaves and trash. There is no requirement for minimum length. Tolerances: 10% for excessively young pods, 15% for other grade defects (5% for pods with worm holes or affected by decay and 2% for decay).
- **Unclassified**

**Cooling:** Very prone to decay if held at room temperature.

- Forced-air cooling for unshelled peas
- Hydro-cooling for shelled peas

**Washing:** Contact with water greatly accelerates deterioration for unshelled peas

**Carton sizes:** 10-12-lb. (4.5-5.4kg) plastic bags (considered equivalent to a shelled bushel) or 1-lb. (0.45kg) bags for shelled peas. Some large operations package peas in vacuum-packed 1 and 10-lb. (0.45 and 4.5kg) bags. Pods for shelling are packed primarily in meshed bags (cabbage sacks) or wooden bushel baskets.



## **Southern Peas**

### **STORAGE**

- Temperature: 39-41°F (4-5°C)
- Humidity: 95%
- Respiration: 8.2-16.9 mL/kg hr at 41°F (5°C) for whole pods and 50-89.4 mL/kg hr at 68°F (20°C) for shelled peas
- Air composition: No information available
- Ethylene producer: Unknown. Probably sensitive to ethylene with effects characterized by yellowing of pods.
- Damage potential: Unknown
- Shelf life: 6-8 days for unshelled peas. 24-48 hr at 39-41°F (4-5°C) for shelled peas

### **PESTS/DISEASES**

Very little research has been done on postharvest pathogens.

Gray Mold (*Botrytis cinerea*): Can quickly develop on pods and shelled peas.

Insect damage: Feeding damage and misshaped peas from stinkbugs and cowpea cucurlio infestation can create major postharvest grading problems.

## Spinach



### HARVEST

Quality: Leaves should be of similar varietal characteristics, fresh, fairly tender and clean, well trimmed, of characteristic color for the variety, free from decay, discoloration, freezing injury, foreign material, disease, insects, and damage caused by coarse stalks or other mechanical means.

Harvest tips:

- Harvest with a field knife, cutting just under ground level and keeping the root intact.
- Bunch in the field: 4-6 plants per bunch (about  $\frac{3}{4}$  lb.).
- Harvest into 24 count field totes.

### HANDLING/PACKING

Grades – Spinach: Dec. 27, 1946

- **U.S. Extra No. 1:** Leaves of similar varietal characteristics that are fairly clean, well trimmed, free from coarse stalks, seedstems, seedbuds, crowns and roots, sandburs or other kinds of burs, decay, and free from damage caused by clusters of leaves, wilting, discoloration, freezing, foreign material, disease, insects, mechanical or other means. Tolerance: 5% (1% for decay).
- **U.S. No. 1:** Leaves of similar varietal characteristics that are well trimmed, free from coarse stalks, seedstems, seedbuds, crowns and roots, sandburs, or other kinds of burs, decay, and free from damage caused by clusters of leaves, wilting, discoloration, freezing, dirt, or other foreign material, disease, insects, mechanical or other means. Tolerance: 10% (1% for decay).
- **U.S. Commercial:** Leaves of similar varietal characteristics that are well trimmed, free from coarse stalks, seedstems, seedbuds, crowns and roots, sandburs, or other kinds of burs, decay, and free from damage caused by clusters of leaves, wilting, discoloration, freezing, dirt or other foreign material, disease, insects, mechanical or other means. Tolerance: 20% (1% for decay).

Cooling: Field heat should be removed as quickly as possible.

- Hydro-cooling
- Liquid icing
- Package icing (2.2-lb. of ice per 4-lb. of product)
- Top-icing

Washing: Clean via hydro-cooling.

Materials: 24 count waxed carton with perforated polyethylene liner.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-98%
- Respiration: 9-11 mL/kg hr at 32°F (0°C)
- Air composition: 5-10% CO<sub>2</sub>, 7-10% O<sub>2</sub>
- Ethylene producer: Low. Very sensitive to ethylene exposure
- Damage potential: *Sensitive to overheating. Spinach is sensitive to bruising during handling.*
- Shelf life: 2 weeks (3 weeks for kale)

### PESTS/DISEASES

Bacterial soft rot:

- Implement appropriate disease control during production.

## Sprouts

### HARVEST

Quality: Fresh mung bean sprouts have crisp white hypocotyls and yellow or green cotyledons. Sprouts are harvested after 1-8 days of growth, depending on the type, and desired plant height and width. For example, mung bean sprouts are normally harvested after 3-8 days when length is 1/2 -3", while alfalfa sprouts are harvested after 1-2 days when length is 1-1 1/2", and radish sprouts after 2 to 4 days when length is 1/2 -1".

### HANDLING/PACKING

Grades: Sprouts are not graded in the U.S.

Cooling: Sprouts should be cooled immediately to 32°F (0°C).

- Hydro-cooling
- Forced-air cooling

Washing: Not necessary.

Carton sizes:

#### Weights:

- Alfalfa: 4-6 oz. containers with 12 containers/case
- Mung bean: 4-6 oz. containers in 5-lb. open flats.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 95-100%
- Respiration: 11 mL/kg hr at 32°F (0°C)
- Air composition: Reduced O<sub>2</sub>, and increased CO<sub>2</sub>
- Ethylene producer: Low
- Damage potential: Highly perishable
- Shelf life: 5-10 days

### PESTS/DISEASES

Decay, sliminess, and musty odors are all signs of deterioration.



## Strawberries



### HARVEST

Quality: A high quality strawberry fruit will be uniformly red in color, firm, flavorful, and free of defects and disease. Sugar content does not increase after harvest; therefore, harvest fully-ripe for best flavor.

### HANDLING/PACKING

Grades: Feb. 23, 2006

- **U.S. No. 1:** Of one variety or have similar varietal characteristics with the cap (calyx) attached. Shall be firm, not overripe or undeveloped, and be free from mold or decay and damage caused by dirt, moisture, foreign matter, disease, insects, or mechanical or other means. Each strawberry shall have not less than  $\frac{3}{4}$  of its surface showing a pink or red color. Tolerance: 10% (5% for serious damage and 2% for decay).
- **U.S. Combination:** A combination of U.S. No. 1 and U.S. No. 2 grades, provided that at least 80% of the strawberries meet the requirements of the U.S. No. 1 grade. Tolerance: 10% (2% for decay).
- **U.S. No. 2:** Free from decay and from serious damage caused by dirt, disease, insects, mechanical or other means. Each strawberry shall have not less than  $\frac{1}{2}$  of its surface showing a pink or red color. Tolerance: 10% (3% for decay).

Cooling: Cooling should begin no later than 1 hr. after harvest.

- Forced-air cooling (recommended)
- Room cooling

Washing: Strawberries should not be washed.

Carton sizes:

**Weights:** Pint or quart open mesh baskets, or clear clamshell containers, held in corrugated fiberboard tray.

**Sizes:**

- U.S. No. 1 and Combination:  $\frac{3}{4}$ " minimum diameter
- U.S. No. 2:  $\frac{5}{8}$ " minimum diameter

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 80-85%
- Respiration: 6-10 mL/kg hr at 32°F (0°C)
- Air composition: MAP for shipment of 10-15% CO<sub>2</sub>
- Ethylene producer: Very low. Not sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 7 days

### PESTS/DISEASES

Gray mold, brown rot, leather rot, and Rhizopus rot:

- Maintain low storage temperatures.
- Cool promptly after harvest.
- Prevent injury.
- Refrigerated shipment with elevated CO<sub>2</sub>.
- Remove damaged berries from storage.

## Summer Squash



### HARVEST

Quality: Tenderness and firmness are the major quality characteristics. The surface of summer squash should be shiny; dullness is a sign of senescence. Fruit should be firm and free of physical injury. Dark green types should be entirely green; yellowish areas are a sign of senescence. Water loss results in a dull surface and loss of firmness.

Harvest tips:

- Harvest with a field knife.
- Wear clean cotton gloves, and be careful not to scratch the squash.
- Wipe squash with gloves to remove dirt, and remove blossom if still attached.
- Zucchini, yellow squash, and crookneck should be 5-7"; patty pan should be 3-4" in diameter.
- Harvest every other day.

### HANDLING/PACKING

Grades: Jan. 6, 1984

- **U.S. No. 1:** Of one variety or have similar varietal characteristics, with stems or portions of stems attached, that are fairly young and fairly tender, fairly well formed, firm, free from decay and breakdown, and from damage caused by discoloration, cuts, bruises and scars, freezing, dirt or other foreign material, disease, insects, mechanical or other means. Tolerance: 10% (5% for serious damage and 1% for decay or breakdown).
- **U.S. No. 2:** Of one variety or have similar varietal characteristics that are not old and tough, but are firm, free from decay and breakdown, and damage caused by freezing, and free from serious damage caused by discoloration, cuts, bruises, scars, dirt or other foreign material, disease, insects, mechanical or other means. Tolerance: 10% (1% for decay or breakdown).

Cooling:

- Room cooling
- Forced-air cooling

Washing: No washing required other than wiping clean.

Materials: 20-lb.  $\frac{5}{9}$  bu. waxed carton. Pack like sardines, with stem-end facing the carton walls to avoid damaging other fruits.

### STORAGE

- Temperature: 41-50°F (5-10°C)
- Humidity: 95%
- Respiration: 12-13 mL/kg hr at 32°F (0°C)
- Air composition: Not commonly used
- Ethylene producer: 0.1-1.0  $\mu$ L/kg hr. Moderately sensitive to ethylene exposure
- Damage potential: Chilling-injury, bruising and scratching
- Shelf life: <2 weeks

### PESTS/DISEASES

Various fungal and bacterial pathogens: Alternaria rot, bacterial soft rot, cottony leak, Fusarium rot, Phytophthora rot, and Rhizopus rot.

- Avoid chilling-injury.

## Sweet Potatoes



### HARVEST

**Quality:** Sweet potato cultivars vary in color (white to cream to orange to purple), flavor (sweet to non-sweet; mild to intensely flavored), and textural properties (firm to very soft). In the U.S., a very sweet, moist textured cooked product is desirable.

### HANDLING/PACKING

**Grades:** Apr. 21, 2005

- **U.S. Extra No. 1:** Similar varietal characteristics that are firm, smooth, fairly clean, fairly well shaped, free from freezing injury, internal breakdown, black rot, other decay or wet breakdown, and free from damage caused by secondary rootlets, sprouts, cuts, bruises, scars, growth cracks, scurf, pox (soil rot), or other diseases, wireworms, weevils, or other insects, or other means. Tolerance: 10% (5% for serious damage and 2% for soft rot or wet breakdown).
- **U.S. No. 1:** Of one type that are firm, fairly smooth, fairly clean, fairly well shaped, free from freezing injury, internal breakdown, black rot, other decay or wet breakdown, and free from damage caused by secondary rootlets, sprouts, cuts, bruises, scars, growth cracks, scurf, pox (soil rot), or other diseases, wireworms, weevils or other insects, or other means. Tolerance: 10% (5% for serious damage and 2% for soft rot or wet breakdown).
- **U.S. No. 1 Petite:** Of one type that are firm, fairly smooth, fairly clean, fairly well shaped, free from freezing injury, internal breakdown, black rot, other decay or wet breakdown, and free from damage caused by secondary rootlets, sprouts, cuts, bruises, scars, growth cracks, scurf, pox (soil rot), or other diseases, wireworms, weevils or other insects, or other means. Tolerance: 10% (5% for serious damage and 2% for soft rot or wet breakdown).
- **U.S. Commercial:** Same as U.S. No. 1, except for an increased tolerance for defects. Tolerance: 25% (5% for serious damage and 2% for soft rot or wet breakdown).
- **U.S. No. 2:** Of one type that are firm and free from freezing injury, internal breakdown, black rot, other decay or wet breakdown, and free from serious damage caused by dirt or other foreign materials, cuts, bruises, scars, growth cracks, pox (soil rot), or other diseases, wireworms, weevils or other insects, or other means. Tolerance: 10% (2% for soft rot or wet breakdown).

**Curing:** Roots should be cured immediately after harvest at 82-86°F (28-30°C) and 90-97% RH for 4-7 days.

**Washing:** *Dry brushing, or gentle hand-washing and partial drying (put in perforated totes to let drain before packing)*

# Sweet Potatoes

Carton sizes:

**Weights:**

- 40-lb. 1  $\frac{1}{9}$  bushel boxes

**Length:**

- U.S. Extra No. 1: 3"-9"
- U.S. No. 1: 3"-9"
- U.S. No. 1 Petite: 3"-7"

**Diameter:**

- U.S. Extra No. 1: 1  $\frac{3}{4}$ " -3  $\frac{1}{4}$ "
- U.S. No. 1: 1  $\frac{3}{4}$ " -3  $\frac{1}{2}$ "
- U.S. No. 1 Petite: 1  $\frac{1}{2}$ " -2  $\frac{1}{4}$ "
- U.S. No. 2: 1  $\frac{1}{2}$ " minimum

**Weight:**

- U.S. Extra No. 1: 18-oz. maximum
- U.S. No. 1: 20-oz. maximum
- U.S. No. 2: 36-oz. maximum

Materials: During storage, roots can be handled in 800 lb. bulk bins.

## STORAGE

- Temperature: 55-59°F (13-15°C)
- Humidity: 90%
- Air composition: Benefit does not outweigh expense
- Ethylene producer: Exposure to ethylene should be avoided
- Damage potential: Chilling-injury
- Shelf life: Up to 1 year

## PESTS/DISEASES

Various microorganisms: Java black rot, black rot, bacterial soft rot, surface rot, root rot, charcoal rot, scurt, and soft rot.

- Minimize damage to roots.
- Immediately cure roots.
- Use proper storage temperature.
- Frequently change wash-water.
- Use calcium hypochlorite in wash-water.

Sweet potato weevil: A serious storage insect pest.

- Infested roots should not be stored.

Fruit flies: Can be a problem when diseased, soured, or damaged roots are in storage.

## Tangerines (Mandarins)



### HARVEST

**Harvest maturity:** Maturity standards require a set minimum SSC:TA ratio and at least 50% peel surface color break.

**Quality:** Shall have a turgid, deep orange-red peel relatively free of blemishes. Fruit should be elliptical and firm. The peel should be easily removed from the flesh and the edible portion should be juicy and contain few or no seeds.

### HANDLING/PACKING

**Grades (Florida):** Feb. 20, 1997

- **U.S. Fancy:** Not more than  $\frac{1}{10}$  of the surface, in the aggregate, may be affected by discoloration. Shall be firm and highly colored, mature and be well formed. Fruit shall be free from caked melanose, decay, unhealed skin breaks and wormy fruit and free from damage caused by ammoniation, bruises, buckskin, creasing, dirt or other foreign material, dryness or mushy condition, disease, green spots, hail, insects, oil spots, scab, scale, scars, skin breakdown, sprayburn, sunburn and by other means. Tolerances: Defects at shipping point: 10% (5% for defects causing very serious damage and 1% for decay or wormy fruit). Defects en route or at destination: 12% (10% for permanent defects or 7% for very serious damage, including 5% for very serious damage by permanent defects and 3% for decay or wormy fruit).
- **U.S. No. 1 Bright:** Same as for U.S. No. 1 except that fruit shall have not more than  $\frac{1}{5}$  of surface, in the aggregate, affected by discoloration. Tolerances: (Defects): As for U.S. Fancy grade. (Discoloration): 10%. No sample may have more than 20% of fruit with excessive discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1:** Not more than  $\frac{1}{3}$  of the surface, in the aggregate, may be affected by discoloration. Shall be fairly well colored, firm, mature, well formed and free from decay, unhealed skin breaks, wormy fruit and damage (as per mechanisms outlined in the U.S. Fancy grade above). Tolerances: (Defects): As for U.S. Fancy grade (Discoloration): As for U.S. No. 1 Bright.
- **U.S. No. 1 Golden:** Same as for U.S. No. 1 except for tolerances. Tolerances: (Defects): As for U.S. Fancy grade. (Discoloration): Not more than 30% shall have in excess of  $\frac{1}{3}$  of their surface, in the aggregate, affected by discoloration, and no part of any tolerance shall be allowed to increase this percentage. No sample may have more than 40% of fruit with excessive discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1 Bronze:** Same as for U.S. No. 1 except for tolerances. The predominating discoloration on each fruit shall be of the rust mite type. Tolerances: (Defects): As for U.S. Fancy grade. (Discoloration): At least 30% shall have in excess of  $\frac{1}{3}$  of the surface, in the aggregate, affected by discoloration, and no part of any tolerance shall be allowed to reduce this percentage. No sample may have less than 20% of the fruit with required discoloration and the entire lot shall average within the percentage specified.
- **U.S. No. 1 Russet:** Same as for U.S. No. 1 except that at least 30% of the fruit shall have more than  $\frac{1}{3}$  of their surface, in the aggregate, affected by any type of discoloration. Tolerances: (Defects): As for U.S. Fancy grade. (Discoloration): As for U.S. No. 1 Bronze.
- **U.S. No. 2 Bright:** Same as for U.S. No. 2 except that fruit shall have not more than  $\frac{1}{5}$  of surface, in the aggregate, affected by discoloration. Tolerances: (Defects): As for U.S. Fancy grade. (Discoloration): As for U.S. No. 1 Bright.
- **U.S. No. 2:** Not more than  $\frac{1}{2}$  of the surface, in the aggregate, may be affected by discoloration and fruit shall be fairly firm. Shall be fairly well formed, mature and reasonably well colored, free from decay, unhealed skin breaks, wormy fruit and damage (as per mechanisms outlined in the U.S. Fancy grade above). Tolerances: (Defects): As for U.S. Fancy grade. (Discoloration): As for U.S. No. 1 Bright.



## Tangerines (Mandarins)

- **U.S. No. 2 Russet:** Same as for U.S. No. 2 except for tolerances. Tolerances (Defects): As for U.S. Fancy grade. (Discoloration): At least 10% shall have in excess of  $\frac{1}{2}$  of the surface, in the aggregate, affected by any type discoloration. No part of any tolerance shall be allowed to reduce this percentage and the entire lot shall average within the percentage specified.
- **U.S. No. 3:** Mature, not flabby and not seriously lumpy. Shall be free from decay, unhealed skin breaks, wormy fruit and very serious damage (as per mechanisms outlined in the U.S. Fancy grade above). Tolerances: Defects at shipping point: 10% (1% for decay or wormy fruit). Defects en route or at destination: 12% (10% for permanent defects or 3% for decay or wormy fruit).

**Sizes:** Shall be fairly uniform in size with not more than 10% shall vary more than  $\frac{1}{2}$ " in diameter. Not more than 10% of the samples in any lot may fail to meet the size requirements.

Grades (States other than Florida): Feb. 27, 1999

- **U.S. Fancy:** Not more than  $\frac{1}{10}$  of the surface of each fruit may have a light shade of brown discoloration. Shall be mature, firm, well formed, free from unhealed skin breaks, dryness or mushy condition, hard or dry skins and decay. Shall be free from injury caused by ammoniation, bruising, creasing, green spots or oil spots, skin breakdown, scale, sprouting, sprayburn and sunburn, and free from damage caused by buckskin, melanose, scars, scab, dirt or other foreign materials, disease, insects, mechanical or other means. Shall be well colored. Tolerances: Defects at shipping point: 10% for discoloration, 10% for other grade requirements (5% for defects causing very serious damage and 1% for decay). Defects en route or at destination: 10% for discoloration, 12% for other grade requirements (10% for permanent defects or 7% for defects causing very serious damage, including 5% for very serious damage by permanent defects and 3% for decay).
- **U.S. No. 1:** Not more than  $\frac{1}{3}$  of the surface of each fruit may have a light shade of brown discoloration. Mature, firm, well formed, free from unhealed skin breaks, hard or dry skins and decay and free from damage by the various mechanisms as outlined in the U.S. Fancy grade above. Shall be fairly well colored. Tolerances: As for U.S. Fancy.
- **U.S. No. 1 Bronze:** Same as for U.S. No. 1 except for discoloration. At least 75% of the fruit shall show some discoloration, and more than 20% shall have more than  $\frac{1}{3}$  of their surface affected with bronzed russeting. No discoloration shall exceed the amount allowed in the U.S. No. 1 grade, unless such discoloration is caused by thrip or wind scars, or rust mite. Tolerances: As for U.S. Fancy.
- **U.S. Combination:** Combination of U.S. No. 1 and U.S. No. 2 tangerines. At least 40% shall meet the requirements of the U.S. No. 1 grade. Tolerances: Defects at shipping point: 10% for U.S. No. 2 discoloration requirements, 10% for other requirements of U.S. No. 2 grade, (5% for very serious damage and 1% percent for decay). Defects en route or at destination: 10% for U.S. No. 2 discoloration requirements, 12% for remaining requirements of U.S. No. 2 grade (10% for permanent defects or 7% for defects causing very serious damage, 5% for very serious damage by permanent defects and 3% for decay). For defects at shipping point and en route or at destination: No part of any tolerance shall be allowed to reduce for the lot as a whole the 40% of U.S. No. 1 tangerines required in the U.S. Combination grade, but individual samples may have not less than 30% of U.S. No. 1 required, provided the entire lot averages within the percentage required.
- **U.S. No. 2:** Not more than  $\frac{2}{3}$  of the surface of each fruit may be affected with light brown discoloration, or may have the equivalent to this amount in appearance when the fruit has lighter or darker shades of discoloration. Shall be mature, fairly firm, fairly well-formed, free from unhealed skin breaks, hard or dry skins and decay and be free from serious damage by the various mechanisms as outlined in the U.S. Fancy grade. Each fruit of this grade shall be reasonably well colored. Tolerances: As for U.S. Fancy.

## Tangerines (Mandarins)

- **U.S. No. 2 Russet:** Same as for U.S. No. 2 except that more than 20% shall have in excess of  $\frac{2}{3}$  of the surface in the aggregate affected with light brown discoloration. Tolerances: As for U.S. Fancy.
- **U.S. No. 3:** Mature, not flabby and not seriously lumpy, free from unhealed skin breaks, hard or dry skins and decay. Shall be free from very serious damage caused by various mechanisms as outlined in the U.S. Fancy grade. Tolerances: Defects at shipping point: 10%, (1% for decay). Defects en route or at destination: 12% (10% for permanent defects and 3% for decay).

**Sizes:** Minimum diameters of tangerines for various pack sizes are outlined in more detail in the standard. Not more than 10% of the fruit in any sample may be below the minimum size.

**Carton sizes:**  $\frac{4}{5}$  bushel cartons are used for shipping and storage. Marketable tangerines range from size 56 (56 fruit/carton) to size 210 (210 fruit/carton)

**Cooling:** Rapid cooling will slow pathogen growth, reduce water loss and increase shelf-life.

- Room cooling
- Forced-air cooling

**Washing:**<sup>17</sup> Brush wash with soap/detergent if necessary

### STORAGE

- Temperature: 41.0-46.4°F (5-8°C)
- Humidity: 95%
- Respiration: 2.1-4.1 mL/kg hr at 41°F (5°C)
- Air composition: No information available
- Ethylene producer: Low. Ethylene can be used for degreening.
- Damage potential: Chilling injury can occur if <41 °F (5 °C). Thiabendazole (TBZ) can be incorporated into fruit coatings and used to control decays during storage.
- Shelf life: 4 weeks

### PESTS/DISEASES

**Stem-end rot** (*Diplodia natalensis* and *Phomopsis citri*): A significant problem especially in areas where degreening is required in early season fruit. Decay develops unevenly at the stem and styler ends resulting in uneven margins.

**Anthraxnose** *Colletotrichum gloesporioides*: Characterized by brown peel lesions appearing on early-season mandarins that have undergone lengthy degreening periods.

- Minimize degreening time by delaying harvest to minimize the above diseases.

**Brown rot** (*Phytophthora citrophthora*): Develops from infections that take place before harvest. Has a characteristic rancid odor and is characterized by tan lesions that quickly overtake the entire fruit under optimum conditions.

- Apply pre-harvest treatment with copper-containing fungicides.

**Green and blue mold** (*Penicillium digitatum* and *P. italicum*, respectively): Develop as a result of wounds made during the harvesting and handling process.

- Drenching mandarins with TBZ before packinghouse arrival is recommended for Diplodia, Phomopsis, Anthracnose and Penicillium control. Application of aqueous imazalil or TBZ in the coating treatment aids in control also.
- Harvest and handle carefully to minimize injuries .
- Practice good sanitation of packinghouse equipment and storage areas.

## Tomatillos



### HARVEST

Harvest maturity: Can be harvested at various stages of development. For commercial marketing, harvest when fruit are well formed and have substantially filled the husk, but are still bright-green. Over-mature fruit that are light-green or yellowing should be avoided since they are sweeter and undesirable for most uses.

Quality: Freshness and greenness of the husk is a criteria. Fruit should be firm and bright green, since the color and acidic flavor are the main culinary contributions of tomatillos.

### HANDLING/PACKING

Grades: Tomatillos are not graded in the U.S.

#### Cooling:

- Forced-air cooling
- Room cooling

Washing: Washing in chlorinated water reduces superficial mold growth, but may be difficult to implement commercially as it is difficult to remove all moisture from inside the husk.

Carton sizes: Fruit are not usually sized before packing. U.S. derived fruit are packed in 10-lb. (4.5kg) cartons

### STORAGE

- Temperature: 41-50°F (5-10°C)
- Humidity: 80-90%
- Respiration: 6.2-7.2 mL/kg hr at 41°F (5°C) for mature-green fruit. Respiration rates of developing fruit are about 25% higher than those of mature fruit.
- Air composition: No information is available
- Ethylene producer: Low for immature tomatillos. More mature fruit produce 1-10 µL/kg hr and rate can be higher in over-mature fruit. Ethylene exposure causes undesirable color changes in mature fruit.
- Damage potential: Chilling-injury can occur after 3 weeks at 41°F (5°C). Symptoms include surface pitting and decay.
- Shelf life: 1 month. At ambient temperatures husks will dry out but the fruit will remain in good condition for about 1 week.

### PESTS/DISEASES

Black mold (*Alternaria alternata*): Occurs especially when fruit has chilling-injury.

- Store under optimum conditions.

Unidentified superficial molds: Occur on husk during storage under high RH conditions.

- Wash in chlorinated water.

## Tomatoes



### HARVEST

**Quality:** High quality fruit have a firm, turgid appearance, uniform and shiny color, without signs of mechanical injuries, shriveling or decay.

**Harvest tips:**

- *Turners/breakers are generally preferred by wholesalers; communicate with your buyer on the maturity desired.*
- *Twist the tomato in a downward motion to leave the stem behind. For some varieties, stem can be flicked off if still remaining; the stem should stay on for some heirloom varieties (you should use pruners to harvest these).*
- *Do not squeeze the tomatoes – they can bruise.*
- *Pack tomatoes stem-side down.*
- *Avoid harvesting when wet.*
- *Wear cotton field gloves and use them to brush dirt off tomatoes in the field.*
- *Unusable tomatoes should be placed in the center aisle for compost.*
- *Tomatoes are commonly field packed.*
- *Tomatoes should be seen and not heard. Handle with care.*
- *Harvest every other day, at least.*

**Maturity stages:**

- **Stage 1:** Mature green. Common in commercial and long-distance production chains. Firm, mature, color change from green to light green, no pink on blossom end. 1-2 weeks in refrigerator. If the seeds are tan and gel is forming in at least two locules, these may ripen to moderate quality. If the seeds are pushed aside when the tomato is sliced and/or when red color appears in the gel and tissue, the tomato will ripen to high quality (provided proper storage).
- **Stage 2:** Pink. Most desirable for local wholesale markets. Pink on blossom end about the size of a dime. Will ripen in 3 days at room temperature. This stage is physiologically mature, and ripening on or off the vine will produce the same level of quality.
- **Stage 3:** Ripe: full red but still firm. Use immediately. These are not suitable for wholesale and are more appropriate for direct marketing, CSAs, and farmers' markets.

### HANDLING/PACKING

**Grades:** Oct. 1, 1991

- **U.S. No. 1:** Similar varietal characteristics, mature, not overripe or soft, clean, well developed, fairly well formed, and fairly smooth. Free from decay, freezing injury, and sunscald. Not damaged by any other cause. Tolerance: Defects at shipping point: 10% for grade requirements (5% for defects causing very serious damage and 1% for being soft or affected by decay). Defects en route or at destination: 15% for grade requirements (5% for being soft or affected by decay, 10% for shoulder bruises or discolored or sunken scars, 10% for being otherwise defective and 5% for very serious damage by any cause, exclusive of soft or decayed tomatoes).

## Tomatoes

- **U.S. Combination:** Consists of a combination of U.S. No. 1 and U.S. No. 2 tomatoes, provided that at least 60%, by count, meet the requirements of the U.S. No. 1 grade. Tolerance: Defects at shipping point: 10% for U.S. No. 2 grade requirements (5% for defects causing very serious damage and 1% for being soft or affected by decay). Defects en route or at destination: 15% for U.S. No. 2 grade requirements (5% for being soft or affected by decay, 10% for serious damage by shoulder bruises or by discolored or sunken scars, 10% for being otherwise defective and 5% for very serious damage by any cause, exclusive of soft or decayed tomatoes).
- **U.S. No. 2:** Same as U.S. No. 1, but may be reasonably well formed, no more than slightly rough, and not seriously damaged by any other cause. Tolerance: Defects at shipping point: 10% for grade requirements (5% for defects causing very serious damage and 1% for being soft or affected by decay). For defects en route or at destination: 15% for grade requirements (5% for being soft or affected by decay, 10% for serious damage by shoulder bruises or by discolored or sunken scars, 10% for being otherwise defective and 5% for very serious damage by any cause, exclusive of soft or decayed tomatoes).
- **U.S. No. 3:** Same as U.S. No. 2, but may be misshapen, and may be slightly damaged by sunscald, but should not be very seriously damaged by causes other than decay and freezing injury. Tolerance: Defects at shipping point: 10% for grade requirements (5% for very serious damage by insects, 1% for being soft or affected by decay). Defects en route or at destination: 15% for grade requirements (5% for being soft or affected by decay, 10% for very serious damage by shoulder bruises or by discolored or sunken scars, 10% for being otherwise defective and 5% for very serious damage by insects).

Tolerance (All grades): Off-size: 10% may be smaller than the specified minimum diameter, or larger than the specified maximum diameter. Off color: 10% may fail to meet the color specified and 5% for tomatoes which are green in color, when any term other than "Green" is specified.

### Cooling:

- Room cooling
- Forced-air cooling produces best results

Washing: Clean with cotton gloves in field.

### Carton sizes:

**Weights:** Lidded, 25-lb. cartons (12"x16"x9 1/2") that stack 10 cartons per layer on a 40" x 48" pallet.

- 20-lb. 2-layer
- 10-lb. one layer
- 12 pints in flat cherry carton

### **Diameter:**

- Small: 2.13-2.28" (5.40-5.79cm)
- Medium: 2.25-2.53" (5.72-6.43cm)
- Large: 2.5-2.78" (6.35-7.06cm)
- Extra-large: at least 2.76" (7cm)

## Tomatoes

### Color:

- Green: 100% green
- Breaker: Tan, yellow, pink, or red on <10% of the surface
- Turning: 10-30% of the surface is not green
- Pink: 30-60% is not green
- Light red: 60-90% is not green. Shows pinkish-red or red
- Red: >90% not green. Red color overall

Materials: Containers should be padded, clean, shallow, and, have smooth bottoms. Tomatoes can be packed in one or two layers.

### STORAGE

- Temperature: 66-70°F (19-21°C) for ripening; <55.4°F (13°C) retards ripening (use only for red tomatoes; can lead to chilling-injury in tomatoes that are not fully ripe); below 55.4°F (13°C) taste is adversely affected.
- Humidity: 90-95%
- Respiration: 15.5-22.8 mL/kg hr at 68°F (20°C)
- Air composition: 2-3% CO<sub>2</sub> for green-ripe and 3-5% CO<sub>2</sub> for red tomatoes; 3-5% O<sub>2</sub> for all types.
- Ethylene producer: 1-10 µL/kg hr. Exposure to 50 µL/L will help green tomatoes ripen. Breaker stage tomatoes do not need introduced ethylene.
- Damage potential: Sensitive to chilling, bruising
- Shelf life: Dependent on maturity when picked

### PESTS/DISEASES

Various decay mechanisms: Soft rot, lactic acid decays, black rot, gray mold rot, Fusarium rot, Mucor rot, Phoma rot, Phomopsis rot, Buckeye rot, Pleospora rot, Rhizopus rot, Ring rot, Sclerotium rot, Sour rot, Target spot, Watery soft rot.

- Avoid bruising or damaging fruit.
- Maintain good standards of hygiene and sanitation.
- Remove and destroy infected fruit.

## Truffles



### HARVEST

Harvest maturity: Maturity indices do not exist, but truffles harvested for immediate sale should be collected during the normal season because they are bigger and develop stronger smell. Truffles harvested at the beginning of the season store better because they have lower water content and are less prone to superficial mold development.

Quality: Characterized by a strong methane-like smell. Large size, soundness, regular shape and uniform distribution of color are important quality characteristics.

Harvest tips:

- Truffles need brushing during washing. Excess water must be removed before storage to avoid growth of superficial mold.
- Special care must be used with mixed loads because truffles can significantly affect the aroma of other commodities.

### HANDLING/PACKING

Grades: Truffles are not graded in the U.S. No commercial standards exist and only the kind of truffle and its geographical origin influences market price.

Cooling: Only summer truffles, or truffles grown in hot areas, need pre-cooling because of their higher metabolic rates. Lowering the temperature helps maintain aroma.

- Hydro-cool to 32°F (0°C). Must be done by immersion.

Washing: Excess wash water should be removed in a well-ventilated room at 39-41°F.

Materials: Quality characteristics and aroma can be maintained in low permeability plastic film packages during storage.

### STORAGE

- Temperature: 32°F (0°C)
- Humidity: 90- 95%
- Respiration: 10-18 mL/kg hr at 32°F (0°C)
- Air composition: High CO<sub>2</sub> maintains aroma better than low O<sub>2</sub> and controls development of superficial molds. High CO<sub>2</sub> should be combined with low O<sub>2</sub> to avoid anoxic conditions. Truffles can be maintained similar to fresh in 60% CO<sub>2</sub> for 35 days at 41°F (5°C).
- Ethylene producer: Very low. Not sensitive to ethylene exposure. Production of ethylene in storage can therefore be a good indicator of internal decay.
- Damage potential: Not chilling sensitive and should be stored as cold as possible without freezing. Attention must be paid to fluctuation of the refrigeration temperature around 32°F (0°C) that could freeze truffles and completely destroy their texture.
- Shelf life: 20-30 days

### PESTS/DISEASES

Worms: Can cause sponginess. The frequent presence of worms inside truffles is often undetectable from the outside.

Bacteria: Are present inside and on the surface of truffles but usually do not cause decay.

## Turnips



### HARVEST

**Quality:** High quality turnips are firm, free of growth cracks, woodiness, rot, injury, and pithiness.

**Harvest tips:**

- *Bunched turnips can be bunched in the field with twist ties. They should be 1-1 1/4 lb. per bunch containing 3-5 turnips.*
- *Remove yellow leaves in the field.*
- *Leave bunched turnips in tank of cold water or in refrigerated truck while waiting to be cooled.*

### HANDLING/PACKING

**Grades:** Aug. 1, 1955

- **U.S. No. 1:** Similar varietal characteristics with roots that are well trimmed, firm, fairly smooth, fairly well shaped, fairly clean, and free from soft rot and damage caused by cuts, discoloration, freezing, growth cracks, pithiness, woodiness, watercore, dry rot, other disease, insects or rodents, or mechanical or other means. Bunched turnips, or turnips with short-trimmed tops shall have tops that are fresh and free from decay and damage caused by discoloration, freezing, disease, insects, or mechanical or other means. Diameter shall not be less than 1 3/4". Tolerance: 10% (5% for serious defects and 1% for soft rot). For tops, when turnips are bunched: 10% (5% for decay).
- **U.S. No. 2:** Similar varietal characteristics with roots that are well trimmed, firm, not excessively rough, not seriously misshapen and free from soft rot and serious damage caused by cuts, dirt, discoloration, freezing, growth cracks, pithiness, woodiness, watercore, dry rot, disease, insects or rodents, or mechanical or other means. Bunched turnips or turnips with short-trimmed tops shall have tops that are fresh and free from decay and damage caused by discoloration, freezing, disease, insects, or mechanical or other means. Diameter shall not be less than 1 3/4". Tolerance: 10% (5% for serious defects and 1% for soft rot). For tops, when turnips are bunched: 10% (5% for decay).
- **Unclassified**

**Cooling:** Can be cooled in wash water, but a temperature differential of 50°F (10°C) or more should be avoided to prevent cracking.

**Washing:** *Barrel wash after storage (for topped turnips). Pressure wash roots only for turnips with tops.*



# Turnips

Carton sizes:

**Weights:**

- 25- or 50-lb. bags
- 1-lb. bags, packed 12 per carton

**Sizes:** (For tops)

- Bunched with tops: 6"+
- Short-trimmed: 4" maximum
- Topped:  $\frac{3}{4}$ " maximum

Materials: Can be packed in vented plastic film or mesh bags.

## **STORAGE**

- Temperature: 32°F (0°C)
- Humidity: 90-95%
- Respiration: 3-4.5 mL/kg hr at 32°F (0°C)
- Air composition: Unknown
- Ethylene producer: Extremely low. Not sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 4-5 months

## **PESTS/DISEASES**

Various rots: Generally resulting from field infection.

## Water Chestnuts



### HARVEST

Harvest maturity: Corms mature after plant tops have died or been killed by frost. Mature corms are recognized by their well-developed, dark, shell-like epidermis. Corms keep well underground and harvest can be delayed for up to 4 months after tops die off. However, corms can become less tender and more fibrous when harvest is delayed.

Quality: There are two types of water chestnuts: sweet hon matai and starchy sui matai, with the former more popular in the U.S. High quality hon matai nuts are tender, crisp and somewhat sweet with white interior tissue. The corms may be eaten raw, but maintain their crispness when cooked. They are usually consumed cooked.

### HANDLING/PACKING

Grades: Water chestnuts are not graded in the U.S.

Cooling: Room cooling

Washing: Wash with water to remove adhering soil and then treat corms with cold chlorinated water (1,000 µL/L; pH 7.0) to reduce decay.

Carton sizes: Usually packed and stored in film bags with moist sphagnum moss.

Sizes: Mature corms 1 1/4" (30mm) in diameter are considered marketable, but corms over 1 1/2" (40mm) in diameter are more desirable

### STORAGE

- Temperature: 32-36°F (0-2°C). Nuts sweeten during low temperature storage.
- Humidity: 98-100%. Store in moist sphagnum moss.
- Respiration: 5.05 mL CO<sub>2</sub> /kg hr at 32°F (0°C)
- Air composition: No information available
- Ethylene producer: No information available
- Damage potential: Chilling-injury is only problematic for immature corms. Symptoms include watersoaking, internal browning and external decay. Can become injured within 10 days at 34°F (1°C), and by 21 days, nuts shrivel and become discolored.
- Shelf life: 1-2 months. Storage life may be extended through submerging undamaged corms in NaOCl solution soon after harvest.

### PESTS/DISEASES

Decay: Mainly due to *Fusarium* and *Geotrichum* spp when stored above 41°F and when immature corms have chilling-injury.

- Store under recommended temperatures.

Black rot (*Cerastomella paradoxa*):

- Cure at 86-90°F (30-32°C) with 100% RH for 3 days.

Trichoderma rot (*Trichoderma viride*): Has been reported in water chestnuts.

# Watercress



## HARVEST

Quality: Watercress should be bright-green and not limp. The leaves of watercress quickly become yellow and slimy when improperly handled.

Harvest tips:

- *Harvest with roots intact, but trim them short with a field knife or scissors.*
- *Harvest before flowering.*

## HANDLING/PACKING

Grades: Watercress is not graded in the U.S.

Cooling: Hydro-cooling is recommended.

Washing: Wash in sanitized water.

Materials: Sold in bunches and can be packed in waxed cartons with top-ice. Watercress can also be packaged in boxes with plastic liners.

## STORAGE

- Temperature: 32°F (0°C)
- Humidity: >95%
- Respiration: 8-14 mL/kg hr at 32°F (0°C)
- Air composition: >7% CO<sub>2</sub>, 5% (or greater) O<sub>2</sub>
- Ethylene producer: Low. Sensitive to ethylene exposure
- Damage potential: Low
- Shelf life: 2-3 weeks (2-3 days without proper humidity)

## PESTS/DISEASES

Bacterial soft rot

- Cool promptly after harvest.

## Watermelon



### HARVEST

Quality: Well formed, symmetrical and uniform in shape with a waxy, bright appearance. The rind should be free of scars, sunburn, and abrasions with no bruising or other physical injury, be free from Anthracnose or other decay, and fruit shall not be overripe.

Harvest tips:

- *Harvest indicators: drying tendril across from melon, bright yellow spot on bottom of melon, deep contrast in skin color, and a resonant thud when tapped.*
- *Eat as many as it takes to make sure they are ripe!*
- *Thin-skinned varieties should be handled like eggs. Drive very slowly!*
- *Harvest every other day.*
- *Wear cotton gloves to harvest.*
- *Brush soil off in field with gloves.*
- *Melons do not ripen to maturity after harvest.*
- *Temperature should remain consistent after harvesting; do not move from cool storage to a warm display area.*
- *Broken melons attract bees; this can be a hazard for workers. If cutting melons in the field to check them, leave cut halves face down to avoid attracting crows and bees.*

### HANDLING/PACKING

Grades: Mar. 23, 2006

- **U.S. Fancy:** Mature, similar varietal characteristics, fairly well formed, and not overripe. Free from Anthracnose, decay, sunscald, and Whiteheart. Free from damage by any means. Tolerance: 8% (4% for serious damage and 1% for Whiteheart, sunscald, Anthracnose, or decay).
- **U.S. No. 1:** Mature, similar varietal characteristics, fairly well formed, and not overripe. Free from Anthracnose, decay, and sunscald. Free from damage by any means. Tolerance: 10% (5% for serious damage, 3% for Anthracnose and 1% for decay).
- **U.S. No. 2:** Mature, similar varietal characteristics, not overripe, and not badly misshapen. Free from Anthracnose, decay, and sunscald. Free from serious damage by any means. Tolerance: 10% (6% for Anthracnose and 1% for decay).

Cooling: Watermelons are not generally pre-cooled.

- Room cooling
- Forced-air cooling

Washing: *Wipe off in field with gloves. Can be water washed if necessary.*

## Watermelon

Carton sizes:

**Weights:**

- 700 lb. corrugated bins (*not for thin-skinned melons*)
- 50-60 lb. cartons

Materials: Cartons should have specially designed inserts to help support the weight of the fruit. *Only brand new cartons should be used.*

### **STORAGE**

- Temperature: 50-59°F (10-15°C)
- Humidity: 90%
- Respiration: 3-5 mL/kg hr at 50°F (10°C)
- Air composition: Not beneficial
- Ethylene producer: Low. Extremely sensitive to ethylene exposure
- Damage potential: Chilling-injury
- Shelf life: 2-3 weeks

### **PESTS/DISEASES**

Various pathogens

- Exclude diseased fruit.
- Maintain good disease control in the field.

## Winter Squash



### HARVEST

Quality: Fully mature, with hard rinds and, except for some striped varieties, solid external color. Flesh of good quality winter squash is bright yellow or orange with a fine, moist texture and high solids, sugars, and starch.

Harvest tips:

- *Should be cut with pruning clippers.*
- *Leave a short stem.*
- *Place in container with care not to scratch neighboring squash.*
- *Avoid wounding squash flesh.*

### HANDLING/PACKING

Grades: Oct. 13, 1983

- **U.S. No. 1:** Similar varietal characteristics, well matured, and not broken or cracked. Free from soft rot or wet breakdown. Free from damage by scars, dry rot, freezing, dirt, disease, insects, and mechanical or other means. Tolerance: 10% (2% for soft rot or wet breakdown or serious damage by dry rot).
- **U.S. No. 2:** Similar varietal characteristics, fairly well matured, and not broken or cracked. Free from soft rot or wet breakdown. Free from serious damage by scars, dry rot, freezing, dirt, disease, insects, and mechanical or other means. Tolerance: 10% (2% for soft rot or wet breakdown or serious damage by dry rot).

Cooling: *No cooling necessary.*

Curing: *Can be sold immediately without curing, or can be cured for longer storage. To cure, place in a warm, ventilated, dry area – greenhouses work well. Bring temperature up to 85-95°F for 8-10 days.*

Washing: *Field brush or brush wash. It is generally considered best to store winter squash unwashed and wash at time of shipment to avoid disturbing the outer wax. Research is being done to determine if storage is more successful when squash is washed at harvest with a sanitizer and then cured and stored. Can tank-dip in wash water with sanitizer before curing.*

Carton sizes:

**Weights:**

- *35-lb. 1 1/9 bu. box*
- *800-900 lb. bulk containers*

### STORAGE

- Temperature: 50-55°F (10-13°C)
- Humidity: 50-70%
- Air composition: Unknown.
- Ethylene producer: Very low. Somewhat sensitive to ethylene exposure
- Damage potential: Moderately chilling-sensitive
- Shelf life: 2-3 months

### PESTS/DISEASES

Various decay agents:

- Avoid chilling-injury.
- Avoid wounding squash flesh.
- Hot water dips at 140°F (60°C) for 2 min.

# WHOLESALE SUCCESS Appendix A: Example Grower Agreement

## 2010 Production and Marketing Agreement Farm name here

This production and marketing agreement was agreed on between  (farmer name)  of  (farm name)  : and  (buyer name)  of  (buyer business name) .

### 1) **Commitment:**

(buyer business name)  agrees to purchase the commodities listed below; The 2008 Marketing Season document, at a price with the price ranges listed.  (buyer business name)  will purchase these agreed upon commodities for the 2008 growing season.

(buyer business name)  agrees that  (farm name)  is their main supply of these products during the marketing season.

Crop	Quantity	Quality	# of Weeks	Price per box
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____
_____	_____	_____	_____	_____

### 2) **Standards:**

- (farm name)  agrees to maintain active organic certification on all items they sell to  (buyer business name) .
- (farm name)  agrees to pack in containers that are acceptable to the organic industry and  (buyer business name) . Containers will contain a farm label on it complete with a lot number.
- (farm name)  will deliver to  (buyer business name) , #1 quality.
- (farm name)  will not knowingly use genetically engineered organisms or food irradiation as part of their production or handling.
- (farm name)  will communicate via fax about projected availability 10 days in advance.

### 3) **Transportation:**

(farm name)  agrees to deliver to  (buyer business name)  on Tuesday, Thursday and Saturday by 7:00 A.M. If either party wishes to change delivery days or delivery times, that communication should occur with at least 1 day advance notice.

# WHOLESALE SUCCESS Appendix A: Example Grower Agreement

## 4) Financial Considerations:

\_\_\_\_\_(buyer business name)\_\_\_\_\_ agrees to pay 10 days net from written invoices that are signed by \_\_\_\_\_(buyer business name)\_\_\_\_\_ produce department employees. All credit requests will be mutually agreed on. \_\_\_\_\_(farm name)\_\_\_\_\_ will provide a credit memo to verify all credits.

## 5) Acts of Nature

Both parties acknowledge that if \_\_\_\_\_(farm name)\_\_\_\_\_ ; due to production problem of drought, hail, or flood or other acts of nature, cannot fulfill this agreement, \_\_\_\_\_(farm name)\_\_\_\_\_ will notify \_\_\_\_\_(buyer business name)\_\_\_\_\_ about the problems and expected result. In this event, \_\_\_\_\_(buyer business name)\_\_\_\_\_ will release \_\_\_\_\_(farm name)\_\_\_\_\_ from any and all expectations to deliver product.

## 6) Marketing of Product

a. \_\_\_\_\_(farm name)\_\_\_\_\_ will provide \_\_\_\_\_(buyer business name)\_\_\_\_\_ with point of purchase materials, such as product stickers and shelf signs.

b. \_\_\_\_\_(farm name)\_\_\_\_\_ will provide 5 farm photos with their negatives (if requested) and will allow \_\_\_\_\_(buyer business name)\_\_\_\_\_ to reproduce, enlarge, and use as a consumer education project.

c. \_\_\_\_\_(farm name)\_\_\_\_\_ agrees to open their farm for a farm tour that would be set up by the \_\_\_\_\_(buyer business name)\_\_\_\_\_ produce manager. \_\_\_\_\_(farmers names)\_\_\_\_\_ will be available to give a farm tour to the registered participants. \_\_\_\_\_(farm name)\_\_\_\_\_ reserves the right to set terms and condition of the tour.

d. \_\_\_\_\_(buyer business name)\_\_\_\_\_ agrees to promote and work to develop brand name recognition of \_\_\_\_\_(farm name)\_\_\_\_\_ product.

## 7) Insurance

\_\_\_\_\_ (farm name) \_\_\_\_\_ agrees to carry general liability insurance coverage of \$1,000,000.

---

farmer name, farm name, date

---

buyer name, business name, date

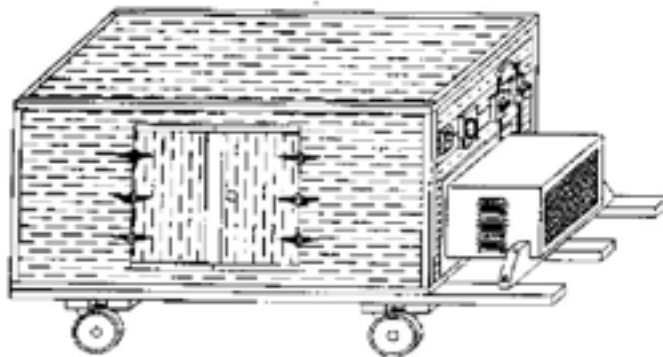


## Building a Portacooler

The Portacooler was originally designed and built by the USDA in Beltsville, Maryland. It is an affordable, do-it-yourself solution to otherwise more expensive options for post-harvest cooling. It is a portable forced-air cooler which can be built for less than \$2,000. It is compatible with all types of produce which can be cooled using forced air, and because it can begin cooling produce immediately after harvest, it is especially useful for highly perishable items such as berries, which have a shelf life of only a few days.

The A/C unit for the Portacooler is not the same as a home unit. Both the cooling capacity and thermostat unit are going to be substantially different. Home A/C units are typically not designed to cool air below 50 or 60 F, though produce needs to be chilled to a temperature between 30 and 40 F. Make sure to select a unit with the appropriate temperature range - indicated by evaporator coil temperature and thermostat range. Because of the large temperature different between the intake and outtake air temperature on this unit, the coils are especially prone to freezing. A simple solution is to install heating strips to prevent frost accumulation on the coils.

The single most expensive item is the air conditioning unit, so reducing its cost will result in a much less expensive unit overall. At the same time, make sure that it is reliable and sturdy, as it will be used for field work and will be moved quite frequently. See below for a complete list of materials and construction diagrams for the Portacooler.

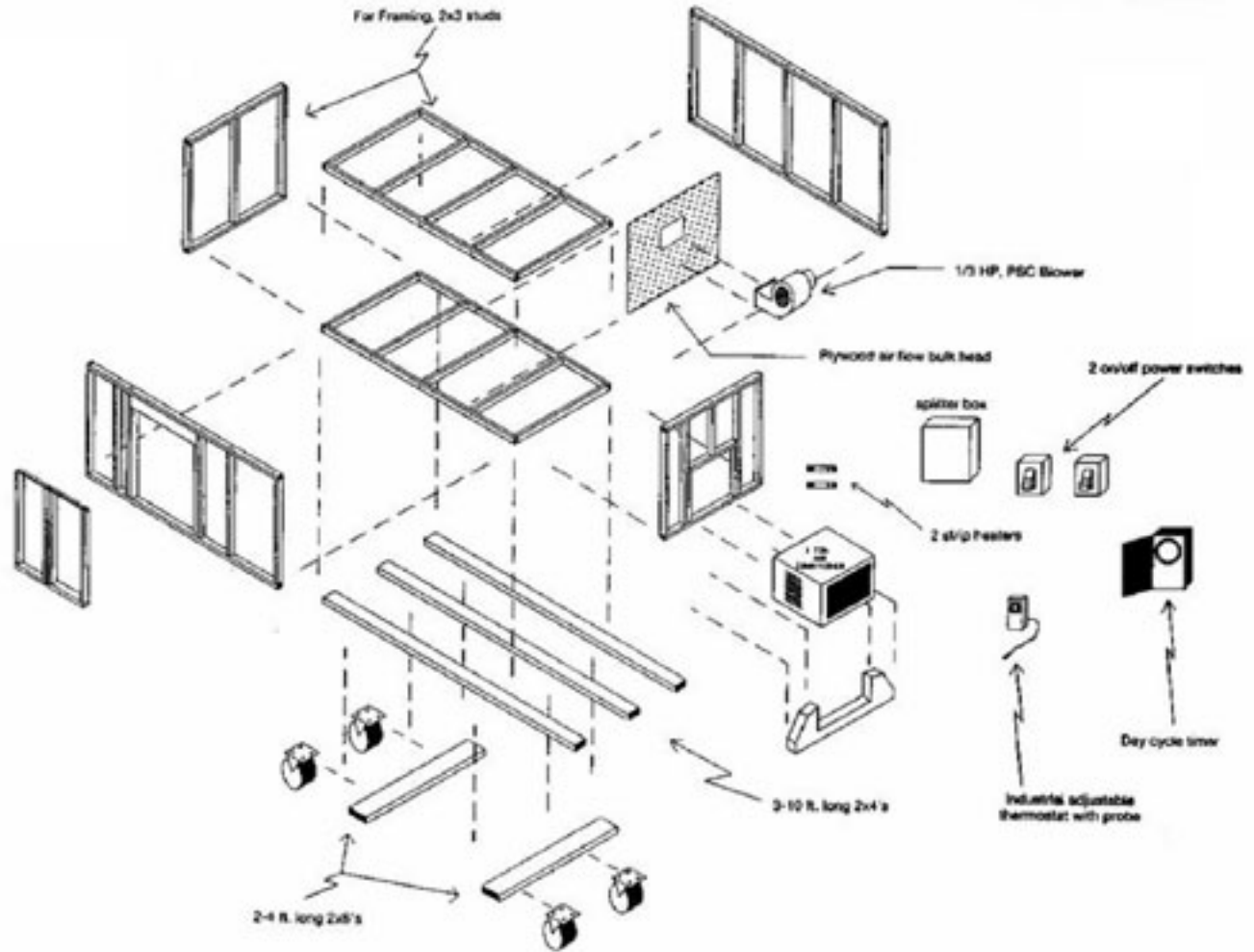


### Portacooler Materials List

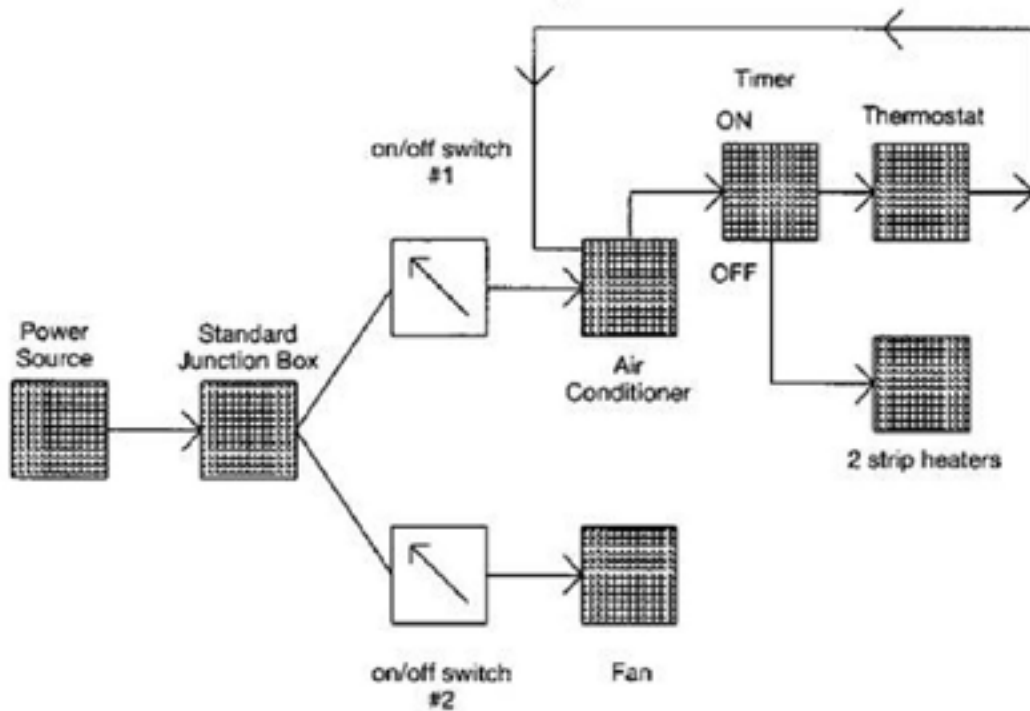
air conditioner, 12,000 btu, 115V	1
centrifugal blower, 1/3 hp, 1210 c.f.m.	1
20 amp wall switch with boxes and covers	2
4' x 8', exterior AC, 1/4" plywood	11
lumber 2" x 3", 8 ft long	30
lumber 2" x 4", 12 ft long	3
lumber 2" x 6", 8 ft long	1
industrial wheels, 5" diameter	2
industrial wheels, 5" diameter, swivel	2
drywall screws 2 1/2" long	5 lb
drywall screws, 1" long	1 lb
water sealer	1 gal
polyurethane coating	1 gal
weather stripping, 1" wide roll	1
insulation, 2", 4' x 8' sheets	5
1/4" plywood, 4" wide strips	12'
door latch, sliding bolt	2
thermostat, 115V, 16 amp, remote bulb	1
strap hinges, screw fastened 3" long	4
lumber, 2" x 10", 4' long	1
standard junction box	1
strip heaters, 150 watt, 8", 115V	2
insulated wire	30'
cycle timer, SPDT, 115V, 20 amp, 1 hour	1

*The design, construction, and research on the Portacooler was conducted by Joseph Anthony, Gerald Berney, William Craig, and Daniel P. Schofer. For further information, contact USDA-Agricultural Marketing Service-TMD, Distribution Service Branch, P.O. Box 96456, Washington, D.C. 20090-6456 or call (202) 720-8357 or (307) 504-8084.*

# WHOLESALE SUCCESS Appendix B: Building a Portacooler



Electrical Diagram



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Reprint permissions were granted for the following images and sections of this book:

- PLU codes section – courtesy of the International Federation for Produce Standards
- Cooling curve figure – courtesy of Adel Kader and UC Davis
- The forced-air, rate of cooling, and package icing pictures – courtesy of North Carolina State University
- The night-air ventilation figure, and the cooling chain sidebar – courtesy of Adel Kader and Lisa Kitinoja and UC Davis
- The respiration rate table – courtesy of L.G. Wilson of North Carolina State University

## Image references

*Figure 1:* Earthbound Farm, CA

*Figure 2:* Meyer, B. et al. University of Wisconsin Healthy Farmers, Healthy Profits Project, May 2000; Third Edition. [http://bse.wisc.edu/HFHP/tipsheets\\_html/cart.htm](http://bse.wisc.edu/HFHP/tipsheets_html/cart.htm)

*Figure 3:* Kader, A. 2002. Postharvest Technology of Horticultural Crops. University of California. 98.

*Figure 4:* Boyette, M. et al. 2000. Forced-Air Cooling. North Carolina State University. <http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-414-3/index.html>

*Figure 5:* Boyette, M. et al. 2000. Forced-Air Cooling. North Carolina State University. <http://www.bae.ncsu.edu/programs/extension/publicat/postharv/ag-414-3/index.html>

*Figure 6:* Boyette, M., and Estes, E. 2000. Crushed and Liquid Ice Cooling. North Carolina State University.

*Figure 7:* Boyette, M., and Estes, E. 2000. Crushed and Liquid Ice Cooling. North Carolina State University.

*Figure 8:* Boyette, M., and Estes, E. 2000. Crushed and Liquid Ice Cooling. North Carolina State University.

*Figure 9:* Kader, A., and Kitinoja, L. 2003. Small-Scale Postharvest Handling Practices; A Manual for Horticultural Crops. 4<sup>th</sup> Edition. University of California, Davis. 121.

*Figure 10:* Meyer, B. et al. 2000. Work Efficiency Tip Sheet: Packing shed layout. University of Madison Wisconsin. [http://bse.wisc.edu/hfhp/tipsheets\\_html/shed.htm](http://bse.wisc.edu/hfhp/tipsheets_html/shed.htm)

*Figure 11:* Ashby, H. 2006. Protecting Perishable Foods During Transport by Truck. USDA. 12.

*Figure 12:* Ashby, H. 2006. Protecting Perishable Foods During Transport by Truck. USDA. 23.

## Endnotes

### Section 1

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<sup>4</sup> Birkerts, E. 2002. The local market opportunity for organic produce: An objective business analysis. The Prairie Partners Group, LLC.

<sup>5</sup> Iowa State University. 2005. Produce Profitability Calculator. [http://www.leopold.iastate.edu/research/marketing\\_files/profitability\\_0108.pdf](http://www.leopold.iastate.edu/research/marketing_files/profitability_0108.pdf)

<sup>6</sup> USDA. 2007. Organic Production. <http://www.ers.usda.gov/Data/Organic/>

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