

# COMMODITY SPECIFIC FOOD SAFETY GUIDELINES FOR THE FRESH TOMATO SUPPLY CHAIN

**Edition 1.0**

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Developed by the  
North American Tomato Trade Work Group  
to Further the Adoption of Good Agricultural Practices  
Throughout the Fresh Tomato Supply Chain

May 2006

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North American Tomato Trade Work Group (United States-Canada-Mexico)

Edward Beckman, California Tomato Commission

Reggie Brown, Florida Tomato Exchange

Kristen Callow, Ontario Greenhouse Vegetable Growers

Murray Drediger and Tom Demma, BC Vegetable Marketing Commission  
Mario Robles, CAADES (Vegetable Commission for Defense, Research and Development)  
Mario Seta, AMPHI (Mexican Greenhouse Vegetable Growers Association)

Tomato Producers and Packers

David Bailey, SunBlest  
Michael Bledsoe, Ph.D., Village Farms  
Tom Deardorff II, Deardorff Jackson  
Jeff Dolan, DiMare Company  
Montserrat Duarte, Agros SA de CV  
Dwight Ferguson, Eurofresh  
Dawn Gray, BC Hothouse Foods  
Billy Heller, Pacific Tomato Growers/EEE Produce  
Dean Janssen, Ace Tomato Company  
Fred Leavitt, Sun Pacific Farming  
Martin Ley, Del Campo  
Mark Munger, A&W Fresh Produce  
Ron Oneto, KLM Ranches  
John Teixeira, Lonewillow Ranch  
Bill Wilber, Oceanside Produce

Trade Members

California Tomato Commission Quality Task Force  
Larry Barton, Darden Restaurants  
Gary Campisi, Wal Mart Stores  
Geoff Cooney, Gordon Food Service  
Bill Piper, Grant County Foods  
Phil Swim, DiMare Fresh  
Ross McKenney, Del Monte Fresh Produce  
Jin Ju Wilder, Coast Produce

Academic Contributor

Dr. Trevor Suslow, University of California, Davis

Government Reviewers

Shirley Bohm, US FDA, CFSAN  
Amy Green, US FDA, CFSAN  
Mary Palumbo, California Department of Health Services  
Michelle Smith, US FDA, CFSAN

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## **FOREWARD**

As farmers, it is our responsibility to provide consumers with a safe and abundant supply of fresh fruits and vegetables. Steps to ensure the safety of our produce include the voluntary adoption of “Good Agricultural Practices” in the mid-1990s that identified potential sources of microbial contamination on the farm and in packing facilities and provided important guidelines for minimizing contamination. In addition, many growers and shippers voluntarily undergo third party audits of their fields and facilities to further ensure the safety of their produce.

However, responsibility regarding food safety should not just be limited to farmers and shippers. The Good Agricultural Practices guidance originally focused on the farm because preventing contamination at the earliest stages of the supply chain is consistent with the principle that preventing contamination is preferred over trying to correct contamination after it occurs. It is important that everyone – farmers, growers, repackers, retailers, restaurants and consumers – take steps to promote food safety. In 2004, the U.S. Food

and Drug Administration (FDA) released a Produce Food Safety Action Plan expanding the produce food safety initiative to cover the entire supply chain. The 2004 Action Plan envisions all interested parties working together and independently to achieve the highest possible safety for fresh produce consumed in the United States.

✓ **A CLOSER LOOK**

*Understanding Fresh Tomatoes and the Threat of Microbial Contamination*

*Most fruits and vegetables eaten fresh in the United States are kept wholesome and free of microorganisms that could result in illness through the use of common and sensible handling and food preparation practices. In addition, many fruits and vegetables have natural barriers that minimize the chances that any surface contamination could be transferred to the internal, edible portions. While not an impervious barrier, the smooth, waxy surface of a tomato has been shown to increase the effectiveness of removal of contamination during washing. Light brush-washing with food-grade disinfectants (such as hypochlorite, chlorine dioxide, ozone, acidified sodium chlorite, or peroxyacetic acid) in combination with food-approved wetting agents largely eliminates surface contamination from globe and roma-type tomatoes at the time of packing. However, research has determined that microbial removal from the stem scar area is particularly difficult to achieve. Of greater concern is the potential for internalization of microbial contaminants during post harvest handling and fresh-cut processing. Contamination of the tomato's outer surface or internal tissues by microbial pathogens can only result, ultimately, from an external environmental source. Although recent laboratory research has demonstrated the high potential for human pathogens to become internalized into tomatoes, under specific exposure conditions, extensive field surveys of fresh market tomatoes have shown that detectable levels of contamination are very rare.<sup>1</sup>*

Fresh tomatoes have been linked to large, multi-state outbreaks of food borne illness at retail and food service outlets as recently as 2002, 2004, and 2005. In the larger outbreaks of 2002 and 2004, Salmonella was identified as the pathogenic agent responsible for illness, and Salmonella was recovered from packaged precut tomatoes at the foodservice outlet.

More must be done to improve the safety of fresh tomatoes to the consumer. On February 5, 2004, the FDA issued a letter to the fresh tomato industry, asking that the industry build upon its past efforts to adopt Good Agricultural Practices and educate the entire production and distribution chain to the importance of preventing microbial contamination.

This document was developed in response to the directive of the FDA and should serve as the baseline for the development of Good Agricultural Practices in the field, greenhouse, packing shed, and throughout the supply chain. NATTWG expresses its appreciation to United Fresh Fruit and Vegetable Association and the Produce Marketing Association for their role in creating an awareness of the need for the development of commodity specific guidance and on-going education throughout the supply chain. Only through the adoption of these guidelines at all levels of the supply chain will the integrity of fresh tomato safety be maintained.

To get the most from this document, we encourage you to read all sections, not simply those that apply to your operation. In doing so, you'll gain an understanding of the importance that all levels of the supply chain have in maintaining the safety established on the farm. You'll note sections that have been labeled "A Closer Look" – these are critical sections dealing with reducing risk from water and human contamination and from improper storage temperatures for freshcut tomatoes. While all issues addressed in this document are important, we urge that you give added attention to these "major risk" areas.

This work is the effort of the North American Tomato Trade Work Group (NATTWG) that was formed by tomato producer organizations and private industry following the conclusion of anti-dumping actions

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<sup>1</sup> TREVOR V. SUSLOW, Extension Research Specialist, Department of Vegetable Crops, University of California, Davis UC DANR Publication 8150.

between the United States and Canada. NATTWG seeks to harmonize tomato trade in North American, including the production of all fresh tomatoes under recognized Good Agricultural Practices.

This document is available on the internet at:

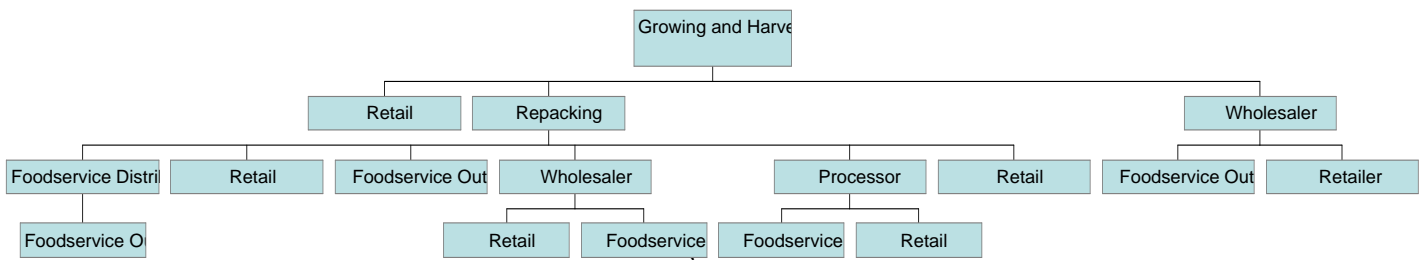
<http://www.tomato.org/ContentAssets/GAP%20May%2010%202006.pdf>

## INTRODUCTION

The diversity of production and processing methods make a single, universally applicable approach to food safety planning in the tomato industry unrealistic and even undesirable as best results come from tailored procedures. Basic Good Agricultural Practices protocol found in the production of fresh produce that applies in the production of field grown tomatoes may also be found in greenhouse production. However, as the production methods are different, there may be specific guidance that is applicable to field producers that may not be applicable to greenhouse producers. The same rationale applies in protocol used in greenhouse tomatoes that may not be employed in the production of field tomatoes.

The distribution chain for fresh tomatoes is unique, in that tomatoes may be sold direct or indirect to the buyer; tomatoes are often subject to repacking for size and/or quality. As a result, there is no single distribution chain. The distribution chain may be simple or very complex, with tomatoes being handled by a number of entities prior to being offered for sale to the consumer. The model distribution chain for the purpose of this document provides an overview of only a few of the many paths a fresh tomato can take prior to the end user:

## DISTRIBUTION CHAIN FOR FRESH TOMATOES



Whether field or greenhouse grown, three basic principles serve as the foundation for all food safety programs found within the industry:

- Once a tomato is contaminated, removing or killing pathogens is difficult.
- Prevention of microbial contamination at all steps from production to distribution is strongly favored over treatments to eliminate contamination after it has occurred.
- Industry supports the implementation and documentation of prevention programs targeted by risk assessment and food safety awareness training for workers at levels of the supply chain.

#### **DISCLAIMER**

In the sections that follow, the production, harvest, packing, repacking, processing and marketing of fresh field and greenhouse tomatoes in accordance with Good Agricultural Practices and key Good Manufacturing Practices is detailed. The guidelines presented are but that – guidelines – and individual growers, shippers, and those who market fresh tomatoes to the consumer should build upon these guidelines to maintain product safety from field to table. The guidelines as presented are the “minimum” requirements for the production and handling of fresh and fresh cut tomatoes. Your own work plan should be developed based upon an analysis of the potential hazards in your production and/or handling of fresh tomatoes. The guidelines, as presented, are not sufficient to serve as an action plan for any given operation. Further, as presented, these guidelines are to supplement, not replace, already established GAP and GMP guidelines for the fresh fruit and vegetable industry. Processing of fresh tomatoes for the pre-cut market requires the adoption of more stringent GMP guidance.

## **PRINCIPLES IN TOMATO PRODUCTION**

As previously noted, environmental considerations and the diversity of production methods make a single, universally applicable approach to food safety planning unrealistic. The guidelines presented should be considered a “starting point” in the development of specific Good Agricultural Practices for field or greenhouse tomato producers that is tailored to an individual operation.

Many of the recommendations to minimize and prevent microbial contamination in the production of field tomatoes are also applicable to greenhouse tomatoes. Although general recommendations may be applicable, production methods for any individual greenhouse are different from field production, and may be different from other forms of greenhouse production. Greenhouse facilities are often unique in their construction and growing methods, thus an exact model for Good Agricultural Practices should be developed based upon the specific facility. Environmental considerations will greatly influence the development of Good Agricultural Practices for the field tomato industry. Such considerations include, but are not limited to: geographic considerations, whether tomatoes are produced in low-lying plains where flooding is possible as compared to more arid flat terrain where flooding does not pose a risk to the crop; whether tomatoes are shed or field packed; and, the presence of wildlife in the field.

There are nine basic principles of microbial safety within the realm of management for growing, harvesting, packing and transporting fresh produce that are applicable in the production of tomatoes and should apply to all forms of tomato production:

Principle 1. Prevention of microbial contamination is favored over reliance on corrective actions once contamination has occurred.

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

Principle 3. The major source of microbial contamination with fresh produce is associated with human or animal feces.

Principle 4. Minimize the potential of microbial contamination from agricultural water used with fresh vegetables by monitoring, documentation and analysis of all agricultural water sources.

Principle 5. Establish a systematic training and education program for all workers; monitor and document; when deficiencies are found, follow through with appropriate corrective action, including remedial training.

Principle 6. Insure facility sanitation through Sanitation Standard Operating Procedures (SSOP) that include scheduled inspections, documented on a regular basis, and are tailored specifically to the facility.

Principle 7. Follow all applicable local, state and federal laws and regulations.

Principle 8. Accountability at all points in the supply chain. There should be qualified personnel and effective monitoring to ensure all elements of the program function correctly and to help track produce back through the distribution channels to the producer should a problem occur.

Principle 9. Conduct annual validated third-party audits of the field and/or greenhouse and packing facility. Audits, however, are only as good as the criteria used for the audit and the experience of the auditor. While many buyers today require such third-party audits, self-audits by qualified personnel are a valuable tool for all points in the distribution chain.



## **GOOD AGRICULTURAL PRACTICES IN THE FIELD OR GREENHOUSE**

*Adopted in part from University of California DANR Publication 8150 and proprietary guidance for the California Tomato Commission, Trevor V. Suslow, Extension Research Specialist, Department of Vegetable Crops, University of California, Davis; from guidance documents provided by Michael E. Bledsoe, Ph.D. Vice President Corporate EHS Officer, Village Farms, L.P.; from proprietary guidance documents of growers, shippers, foodservice and retail contributors to this document.*

### **The Importance of Water Quality**

Wherever water comes into contact with fresh produce, the quality of the water may directly determine the potential for pathogen contamination. Water may be the most important risk to consider when developing a GAP program because of its presence at nearly all stages of growth, processing, and packing. Contaminated water may come into contact with soil, equipment, or containers, which in turn come into contact with fresh tomatoes.

Field producers must give consideration to the control of microbial contamination in the selection of production sites. Consideration should be given to topography, land history, adjacent land, and movement of animals. All producers must recognize the importance of water quality in their production of fresh tomatoes.

- Become familiar with the routes and handling of surface water sources, seasonal influences on water quality, and any microbial monitoring programs followed by the supplier of delivered water from public or private irrigation districts or wastewater reclamation facilities.
- Identify potential sources of contamination that could affect your water, especially those that are within your ability to control in a manner that would protect water quality.
- Ensure that wells are designed and maintained in a manner that prevents surface runoff or soil infiltration from contaminating the water supply. Take corrective action to correct any cracks in wells. If a well is contaminated, use an alternate source or chlorine injection system.
- Water should be sampled and tested for coliforms, fecal coliforms and generic E. coli at the onset of crop production, and should be demonstrated to be potable. Because water sources may be susceptible to the environment, any test of water quality will only give data for that location and time. Thus, source and environmental conditions (drought, rains, flood, etc) may require additional testing at the time of the event.
  - If the water source is downstream from animal grazing lands, have the water tested regularly while controlling the risks from such lands. In the event of a flood, immediately test for contamination.
- International water quality standards for unrestricted crop application use a threshold of less than 1000 fecal coliforms per 100 ml of tested water. State regulations can be far more stringent. It is important to understand local regulations to prohibit produce contact with water that is determined to be contaminated with pathogens.
- Water used for any foliar applications should come from a pathogen-free source.

### **Manure and Municipal Biosolids**

Most commercial field tomato producers do not use manure or municipal biosolids in their production. Amendments commonly used in commercial production include gypsum, soil sulfur, and sulfuric acid. These amendments are generally recognized as being free of microbial risk. Properly composted manures or municipal biosolids are generally not a source of microbial pathogens on fresh produce. Tomato producers who farm adjacent to lands where manure is used must be aware of the potential risks from runoff or flooding. No raw animal manure or leachate from raw material should be used to supplement the soil.

- Become informed about proper compost management for pathogen reduction and document the methods used to eliminate pathogens from any manure that you apply.
- Document or obtain documentation about the specific composition of the compost and composting management, (e.g., time, temperature, turning) for each lot.
- Maximize the time between the date you apply manure to production areas and the date you harvest those areas.
- In any ranch or production block where you use multi-season drip irrigation, pay special attention when spreading chicken manure or litter without incorporating it into the soil to ensure that pathogen reduction practices have been followed and documented.

#### Minimizing Animal Fecal Contamination

It is not possible to eliminate all animal influences from production fields. All the same, you need to determine what steps you can take to minimize their presence and activities. Fecal contamination carries the same risk as raw manure.

- Evaluate the need for bare soil buffers between your tomato fields and water sources and/or adjacent land. Buffer zones can discourage the movement of reptiles, amphibians, and rodents—all potential sources of contamination—into your fields.
- Minimize the presence of vector attractants (such as cull piles and standing water) within a production field.
- Domestic animals should be excluded from tomato fields.

#### Worker Health and Hygiene

As fresh tomatoes, field and greenhouse, are harvested by hand, there is the opportunity for workers to introduce microbial contamination. Controlling the risk requires not only good personal hygiene on the part of the worker, but also good training and follow-up by supervisors. There is no substitute for awareness, training, and constant reinforcement of the importance of each worker's personal hygiene and sanitation as critical elements in maintaining a sustainable business for you and continued employment for the worker.

- Follow all OSHA and/or FDA Title 21 CFR 110 requirements for sanitary facilities. Providing easily accessible toilet and hand washing facilities for workers to use is critical for preventing contamination of tomatoes by workers.
- Establish a training program that includes proper hand washing techniques and the importance of using toilet facilities.
- Establish and communicate a clear policy that allows workers report illness and that allows workers who are observed to have symptoms of illness, vomiting or diarrhea to be reassigned to paid activities that do not involve contact with food or food surfaces. In the absence of such a policy, it is likely that workers will not report their illness for fear that they will lose wages.

- Provide bandages and/or other protective waterproof coverings to workers who have infected cuts or lesions with pus that may make contact with fresh produce.
- If the workers use gloves, provide instruction on their proper use to prevent pathogen transfer to fresh tomatoes or packing surfaces and packed containers.
- Use caution when servicing portable toilets to prevent leakage into a field.
- Provide physical diversion and containment in the event of waste spillage. Have a plan for how to isolate and destroy contaminated produce in the event of a spill.
- Eating and drinking should be prohibited in production areas because they may attract pests. Smoking should also be prohibited.

### Field and Harvest Sanitation

All surfaces and implements that touch fresh produce should be treated as food contact surfaces.

- Clean and sanitize all food contact surfaces and harvest containers or bins as needed.
- Ensure that harvest contractors and crews are aware of the principles of microbial food safety risk reduction and that they adhere to your established food safety practices.
- Minimize the opportunity for disease vectors (rodents, birds, flies, reptiles, amphibians, etc.) to contaminate packing surfaces and materials.
- Minimize vectors' access or attraction to harvest equipment kept in the field (for instance, do not leave damaged fruit or heavy juice residues on buckets, belts, in bins, or in trailers and gondolas).

### Packing Facilities

Packing shed operations vary significantly between growers. A packing shed can be anything from a pole barn in a field to a high-tech enclosed building far from the field. Greenhouse growers usually pack on-site. Well-designed and operated centralized packing facilities and packing systems can contribute to the reduction of pathogen contamination but not its elimination. Management lapses in facilities or system management can amplify localized contamination, broadly redistribute pathogens, and create opportunities for pathogen contamination within the facility. Packing facilities are regulated under Good Manufacturing Practices (GMP), in Chapter 21 of the Code of Federal Regulation, part 100 (21CFR110). Since actual critical control points are not defined where microbial contamination can be eliminated from fresh tomatoes, the sanitary conditions in the packing facility is critical to product safety.

- Design and maintain packing surfaces and equipment to minimize injury to the produce and to maximize accessibility for cleaning and sanitizing.
- Catwalks should be made of metal and should prevent dirt or other debris from falling onto dump tanks and flumes, belts, conveyors, and sorting or grading tables.
- Maintain surfaces of bump pads, brush rollers, sponge rollers, and other equipment to minimize micro injury or other damage to fruit. Minor surface micro injuries that would not result in the culling of a tomato have been shown to promote survival of pathogens, especially in combination with fruit waxes.
- Determine the need, frequency, and process for effectively cleaning and sanitizing rollers and brushes. Although a set schedule may be workable, the volume of product handled may require more frequent attention to cleaning and sanitizing.

- Establish routine cleaning and sanitizing programs for all food contact surfaces.
- Field producers should remove as much dirt as is practical from harvest containers, trailers, and gondolas between harvest uses. This should be done outside the packing facility, away from any water source used for post harvest handling.
- Inspect and clean pallets, containers, or bins as needed. The reuse of containers or cartons in a tomato operation should be carefully evaluated for any food safety risks.
- Establish and maintain a pest control program.
- Prevent birds or other vectors from contaminating packing equipment surfaces, packing areas, and storage areas.
- Store unformed or empty containers off the floor or bare soil surface and in a way that protects them from contamination.
- Ensure that diluted fruit waxes and sheens do not become contaminated with non-potable water or by the transfer hose on the packinghouse floor.

#### Post Harvest Water During Packing

If tomatoes are washed, the quality of post harvest water that contacts fresh produce during post harvest flume transport, cleaning, grading, cooling, and surface treatment application is widely recognized as an essential pathogen control point for fresh produce. Follow Good Manufacturing Practices (GMP) to ensure that all water is of adequate quality throughout all packing operations from start-up to the last packed unit. Water used in post-harvest operations must be changed as necessary for the given operation. Water used in the first dump tank may need to be changed more frequently than water used in the last dump tank.

- Investigations led to the recommendation that post harvest immersion water should be maintained at temperatures 10 oF (6.6oC) above the incoming fruit pulp temperature. Since the porosity of the stem-end scar increases with fruit pulp temperature, the potential for infiltration is highest during peak summer temperatures. The air spaces in tomatoes received at high field-heat temperatures will constrict when submerged in chilled water. As air space volume decreases during fruit cooling, a vacuum effect will draw water from the dump tank or flume into the fruit, especially at the stem-end scar. Infiltration can also occur by pressure if tomatoes are submerged too deep in a wash tank. A general recommendation is: More than one foot of water for more than one minute is too deep and too long.
- The same strategy for prevention of infiltration of foodborne pathogens has potential benefits in post harvest disease control. Remember: Water quality is a critical contributing factor to both food safety and product quality. Post harvest pathologists have been familiar with this mechanism of inoculation of tomatoes with plant pathogens for many years. Post harvest losses due to Bacterial Soft Rot (*Erwinia*, *Pseudomonas*, and others), *Geotrichum* Sour Rot, *Rhizopus* Rot, and *Botrytis* Gray Mold are greater without attention to proper water management to prevent infiltration. Practices vary but a common set point temperature is 40 oC (104oF). Heating immersion water to higher temperatures, 55 to 58 oC (131 to 136.4oF), has been shown to significantly reduce the rate of disease of tomatoes by major post harvest pathogens.<sup>2</sup>
- Being able to do something for both food safety and quality reasons may improve motivation; quality is also something that many people are familiar and comfortable with. Take care to keep the emphasis on the safety objectives of this document.

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<sup>2</sup> Prevention of Post harvest Water Infiltration into Fresh Market Tomatoes: Food Safety and Spoilage Control Practices  
T.V. Suslow

✓ **A Closer Look**

*Key Points to Tomato Dump Tank Management*<sup>3</sup>

- *Reduce the necessity and cost of heating water to high temperatures by providing shade to fruit in bins or gondolas within the pre-grade staging area and by restricting submersion times to less than one minute and one layer of fruit.*
- *If heated dump tank and flume water is used, do not use surfactants or excessive chlorination as this will increase the rate and volume of infiltration.*
- *Determine the specific “Safe Area” for your tomato varieties, meaning, temperature range that does not cause heat damage to the fruit.*
- *Balance the need for infiltration prevention and the high temperature -loss of free chlorine. High water temperatures also increase organic reactions creating chlorination by-products that have known or potential health risks.*
- *Maintaining an ORP (Oxidation Reduction Potential) of at least 650 mV provides sufficient hypochlorous acid (HOCl from chlorine or hypochlorite) or solubilized ozone (O<sub>3</sub>) to kill bacteria (such as E. coli, Salmonella, or Erwinia) freely suspended in water in less than 30 secs. (Please see Appendix to learn about ORP)*
- *Remember that chlorination or other treatments may not eliminate fungal pathogens less sensitive to disinfectants, such as Rhizopus and Botrytis; therefore water disinfection should not be relied upon to prevent the negative consequences of infiltration and possible infection by plant pathogens or microbial contamination.*

## **FOOD SAFETY PROGRAMS FOR THE FIELD, GREENHOUSE AND PACKING FACILITY**

Food safety programs are designed to document your effort to minimize the risks from microbial contamination. Management of these records and on-site audits can seem overwhelming, but are an essential component of any food safety program. You’ll learn from your documentation and will be able to monitor the effectiveness of your program, and be able to respond quickly to third-party auditors.

### Field and Greenhouse Audits

Field tomatoes are those produced in the field, uncovered and open to the environment.

The greenhouse is typically defined as a steel structure whose roof and sides are transparent or translucent glass or plastic, permitting a sufficient quality and quantity of solar radiation to enter the structure for photosynthesis. It allows the growing of crops independently of the outside climate, since its interior temperature, irrigation, sunlight, CO<sub>2</sub> levels and humidity are often controlled by climate computer monitoring.

Field and Greenhouse validated third-party and self-audits should cover the following topics:

- Substrates Use
- Fertilizer Usage
- Water Quality
- Pesticide Usage and Control

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<sup>3</sup> Ibid.

- Employee Safety and Hygiene
- Harvest Practices
- Product Traceability/Recall Program
- Food Security
- Employee Safety and Hygiene Training

Packinghouse Audits

The packinghouse is defined as an obviously designated area inside the facility dedicated to the washing (where applicable), sorting, packing and transporting of fresh produce from the field and greenhouse. Packinghouse validated and self-audits should cover the following topics:

- Good Manufacturing Practices
- Food Safety File Requirements
- Food Security
- Documented Employee Safety and Hygiene Training

Recordkeeping

As part of a recognized Good Agricultural Program, and required as part of the auditing process, producers, packing sheds, repackers, and others in the supply chain may maintain a number of recording logs. Your documentation should include the ability to trace-back all product received from growers. The logs you'll establish will be based upon the scope of your operation. You may be required to establish base-line parameters to monitor the efficiency and efficacy of your operations. Such parameters should always be based upon science, guidelines contained in this document, or applicable local, state, or federal regulations.

Sample Listing of Standard Operating Procedures Recording Logs Used in the Industry

1	Water Usage	Microbiological Contamination of Recycled Water
2	Water Usage	Water Sampling Monitoring Log
3	Water Usage	Well Water Monitoring Log
4	Water Usage	Water Duct Produce Transportation System Log
5	Water Usage	Microbiological Contamination Storage Tank Water
6	Water Usage	Irrigation Pond Water Monitoring
7	Equipment	Scales Calibration
8	Equipment	Thermometer Calibration Log
9	Pest Control	Insect Control Device Monitoring Log
10	Pest Control	Rodent and/or Bird Control Device Monitoring Log
11	Human Resource	Employee Education and Training Log
12	Human Resource	Employee Hygiene and Sanitation Agreement
13	Human Resource	Employee Non-Compliance Form
14	Sanitation	Daily Pre-Inspection Log
15	Sanitation	Master Sanitation Schedule Log

16	Sanitation	Housekeeping Sanitation Schedule Log
17	Sanitation	Hand Wash Station Monitoring Log
18	Sanitation	Disinfectant Foot-Mat Monitoring Log
19	Sanitation	Portable Toilet Monitoring Log
20	Operational	Foreign Material Inspection Log
21	Operational	Incoming Raw Product Receiving Log
22	Operational	Shipping Carrier Monitoring Log
23	Operational	Shipping Dock Controlled Temperature Log NUOCA (Notice of Unusual Occurrence and Corrective Action)
24	Operational	Maintenance Temporary Repair Log
25	Operational	Dropped Produce on Floor Monitoring Log
26	Operational	Equipment Post-Maintenance Sanitation Log
27	Operational	Microbial (Total) Testing - Facility Log
28	Operational	Microbial (Coli form) Testing - Equipment Log
29	Operational	Microbial (E-Coli) Testing - Product Log
30	Operational	Dump Tank Chlorination Monitoring Log
31	Operational	

## **KEY POINTS IN THE SUPPLY CHAIN FOR FRESH TOMATOES: STORAGE AND TRANSPORTATION AT ALL LEVELS OF THE SUPPLY CHAIN**

No matter your level in the supply chain, fresh tomatoes should be stored in a clean location using an organized system. Codes and inventory rotation are important to minimize the time that tomatoes are stored and to facilitate recall. Boxes of product should be placed on pallets to avoid direct contact with floors. Chemicals, trash, waste or odorous material must not be stored near product. Tomatoes must be stored at proper temperatures and humidity to prevent or delay microbial growth. The proper storage temperature and relative humidity will vary considerably depending on type of tomato being handled and its specific requirements. Walls, floors and ceilings must be systematically and periodically cleaned.

### Storage and Ripening

Optimum storage temperatures can help reduce microbial growth.<sup>4</sup>

- Forced-air coolers and ripening rooms are especially susceptible to microbial accumulation because they are often not subject to routine cleaning. A sanitation program should be established to minimize risk.
- Coolers should be cleaned, rinsed, and sanitized at least once a month. Incorporating quat sanitizers in the cleaning procedure can help lower the risk from *Listeria*.
- The cooling unit should have a dehumidifying function to limit excessive moisture.
- Floors should be kept clean and dry.

### Transportation

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<sup>4</sup> Detailed handling information on fresh tomatoes is found in the Appendix of this document.

Contamination on the inside of a truck can lead to the contamination of the product.

- Ensure that transporters, distributors, and others maintain the integrity of the positive lot identification and trace-back systems that have been implemented by the grower and shipper.
- Inspect transportation vehicles for cleanliness, odors, and obvious dirt and debris before loading. If necessary, insist that trailers or containers be cleaned and sanitized before loading.
- Ideally, owner-operators of transport vehicles should have documentation of the prior three loads in the trailer that could be reviewed if there were concerns about chemical or biological contaminants following a loading dock inspection for cleanliness and the presence of unwanted odors.
- Trailers should be fitted with security seals in the distribution chain. Additional seals should be provided in the event the trailer is opened by Customs officials in transit between countries. Their usage should be documented.

#### Mixed Load Transportation

Well-designed and operated wholesale distribution, load consolidation, and cross-docking facilities can maintain the integrity of a pathogen-free product. Lapses in facility sanitation or system management can amplify localized contamination, promote internalization of pathogens into products, and broadly redistribute pathogens. Mixed storage and mixed-load distribution can transfer contamination from one lot or product to another that was not previously contaminated, especially where pallet stacking and mixed loads of wet or iced product are involved.

- Be aware of the potential for cross-contamination.
- Separate dry and wet products and place water-repellant shipping barriers between commodities in mixed loads.



## **KEY POINTS IN THE SUPPLY CHAIN FOR FRESH TOMATOES: WHOLESALE AND REPACKING**

A comprehensive program should be developed for wholesalers and repackers that identifies all potential contamination risks in all areas and all equipment; the program should follow mandated GMP as required, and all finished product should be subject to a formal recall program, with product traceable to the packing shed, grower, and field.

The diversity of handling practices at repack operations make a single, universally applicable approach to food safety planning unrealistic and undesirable. No prescriptive, one-size-fits-all, solutions are appropriate until a risk assessment has been done by qualified personnel with a strong working knowledge of that particular operation. This document summarizes key points in tomato handling; it is not intended to address all requirements under standard GMP.

### Repack Operations

Well-designed and operated repack operations and associated facilities can maintain the integrity of a pathogen-free product. Lapses in facility sanitation or system management can amplify localized contamination, promote internalization of pathogens into products, and broadly redistribute pathogens.

### Worker Health and Hygiene

There is no substitute for awareness, training, and constant reinforcement of the importance of each worker's personal hygiene and sanitation as critical elements in maintaining a sustainable business for you and continued employment for the worker.

- Follow all OSHA and/or FDA Title 21 CFR 110 requirements for sanitary facilities. Providing easily accessible toilet and hand washing facilities for workers to use is critical for preventing contamination of tomatoes by workers.
- Establish a training program that includes proper hand washing techniques and the importance of using toilet facilities.
- Establish and communicate a clear policy that allows workers to report illness and that allows workers who are observed to have symptoms of illness, vomiting or diarrhea to be reassigned to paid activities that do not involve contact with food or food surfaces. In the absence of such a policy, it is likely that workers will not report their illness for fear that they will lose wages.
- Employees inspecting and handling the tomatoes should be trained and adhere to correct hand washing and sanitizing techniques. A hand washing sink with running hot water (110 F – 120 F), liquid soap and hand sanitizer should be readily available. Hand sanitizer dips are recommended in addition to hand washing. Vinyl fitted food handler gloves, latex and/or neoprene gloves should be

available for employees to cover bandaged wounds or cuts to the hand. Clean aprons and hairnets should be worn by employees that come in contact with the tomatoes.

### Product Flow

- Product flow should be linear; incoming product should not cross paths or be stored next to cleaned or processed product. Ideally, packing areas should be physically separated from receiving and processing areas.
- All repack surfaces should be treated as food contact surfaces, and appropriate daily cleaning and sanitizing measures should be implemented and documented.
- If a washing step is included in the repack line, post harvest immersion water should be maintained at temperatures 10 oF (6.6oC) above the incoming fruit pulp temperature. Tomatoes should then be washed in a chlorine bath prior to color sorting/sizing at the repack facility. The concentration of chlorine should be kept at 90-200ppm (total chlorine) and the pH between 6.0-7.0. Chlorine and pH levels in the water should be monitored for proper concentration at a frequency sufficient to ensure that it is of appropriate microbiological quality for its intended use.
  - After rinsing and drying, the ripened tomatoes should be sorted for color, size and defects, then packed into their original shipping container or a new container properly labeled to include the name of the repacker and trace-back identification.<sup>5</sup>
  - Stems may be removed from tomatoes to avoid stem punctures.
- Ideally, no lots of tomatoes should ever be mixed, especially from different suppliers. In cases when avoiding co-mingling is not practical, ample and clear documentation and records should be maintained in the event of a product recall.
- If repack operations place sorted fruit into the same shipping cartons, assign someone to inspect each carton to ensure that it meets adequate standards for cleanliness and is suitable to transport fresh food

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<sup>5</sup> In California, a carton can be reused only by the original grower or a repacker who is registered with the state. Any repacking of tomatoes into containers should include a clear statement on the carton that the product was repacked. Adequate documentation of carton reuse should be maintained by the repacker, including any lot co-mingling.

## **KEY POINTS IN THE SUPPLY CHAIN FOR FRESH TOMATOES: VALUE ADDED PROCESSING – FOODSERVICE AND RETAIL**

It should be noted that, according to Center for Disease Control statistics, 83 percent of traceable produce related outbreaks are due to improper handling, preparation or cross-contamination of food after leaving production fields and facilities. There have been recorded incidents where facilities have received unwashed tomatoes, placed them into ripening rooms, then into ice water baths to firm the tomatoes for processing. Such practices may lead to water infiltration and the microbial contamination of the tomatoes. It is essential that processors be familiar with their suppliers, whether the tomatoes have been washed, and develop appropriate steps to maintain water quality and minimize the potential for infiltration.

A program should be developed that identifies all potential contamination risks in all areas and all equipment; the program should be HACCP based, incorporate GMP as required, and all finished product should be subject to a formal recall program, with product traceable to the packing shed, grower, and field.

The diversity of handling practices at repack and in value-added processing operations make a single, universally applicable approach to food safety planning unrealistic and undesirable. No prescriptive, one-size-fits-all, solutions are appropriate until a risk assessment has been done by qualified personnel with a strong working knowledge of that particular operation. This document is not intended to provide a comprehensive recommendation on value added processing, as such practices are under the guidance of GMP. You are encouraged to follow all applicable federal regulations, which can help minimize the potential for microbial contamination.

### Facilities Planning

Well-designed and operated processing facilities can contribute to the reduction of pathogen contamination. Lapses in facility or system management can amplify localized contamination, broadly redistribute pathogens to the edible fruit, and contaminate pathogen-free tomatoes from within the facility during handling.

- Develop worker-training programs for fruit handling and processing to prevent bare-hand or gloved-hand contact of unclean fruit and cut fruit flesh, in sequence, by the same individual.
- Worker traffic flow and activities should not move between packing and receiving.

### Sanitation

It's important to consider that any area where bacteria are able to accumulate will become a contamination point for all products and water that passes through it. This can result in the contamination of everything downstream. It is imperative to establish an effective sanitation program that includes a documented sanitation schedule, specific cleaning instructions, including types of cleansers. Sanitation procedures should always follow a clean-rinse-sanitize schedule. Although a specific schedule should be established only after an audit by a qualified personnel with a strong working knowledge of that particular operation, sample schedule may include, but not be limited to:

- Dry clean by sweeping floors and wiping down equipment.
- Pre-rinse the equipment.
- Visually inspect equipment surfaces.
- Apply cleanser and/or foam, scrub equipment from top, downward – do not allow detergent to dry on the equipment.

- Rinse from top to bottom.
- Visually inspect all equipment surfaces.
- Clear floors with appropriate cleanser.
- Sanitize equipment and floors.

### Worker Health and Hygiene

There is no substitute for awareness, training, and constant reinforcement of the importance of each worker's personal hygiene and sanitation as critical elements in maintaining a sustainable business for you and continued employment for the worker.

- Follow all OSHA and/or FDA Title 21 CFR 110 requirements for sanitary facilities. Providing easily accessible toilet and hand washing facilities for workers to use is critical for preventing contamination of tomatoes by workers.
- Establish and communicate a clear policy that allows workers to report illness and that allows workers who are observed to have symptoms of illness, vomiting or diarrhea to be reassigned to paid activities that do not involve contact with food or food surfaces. In the absence of such a policy, it is likely that workers will not report their illness for fear that they will lose wages.
- Employees inspecting and handling the tomatoes should be trained and adhere to correct hand washing and sanitizing techniques. A hand washing sink with running hot water (110 F – 120 F), liquid soap and hand sanitizer should be readily available. Hand sanitizer dips are recommended in addition to hand washing. Vinyl fitted food handler gloves, latex and/or neoprene gloves should be available for employees to cover bandaged wounds or cuts to the hand. Clean aprons and hairnets should be worn by employees that come in contact with the tomatoes.

### ✓ **A CLOSER LOOK**

#### *Worker Health*

*“Any person who, by medical examination or supervisory observation, is shown to have, or appears to have, an illness, open lesion, including boils, sores, or infected wounds, or any other abnormal source of microbial contamination by which there is a reasonable possibility of food, food-contact surfaces, or food packaging materials becoming contaminated, shall be excluded from any operations which may be expected to result in such contamination until the condition is corrected.” (21CFR110.10)*

### Produce Sourcing and Handling

All finished product should be traceable from the repacker to the packing shed, grower and field. The traceability program should have the ability to trace all products all the way back to the field and date of harvest.

- Use only good quality fruit, free of open wounds or defects that may have allowed bacteria to become internalized. Avoid fruit that have visible sunken areas or areas of mold or decay.
- Washing in combination with wash water, disinfectant treatment reduces but does not eliminate microbial contamination on the surface of the tomato. If pathogens become internalized, they cannot be reached at all. Proper temperature management (cold chain control) is important for

quality and safety management but cannot be relied upon, alone, to provide sufficient consumer protection from potential foodborne illness.

- Antimicrobial chemicals help minimize the potential for microbial contamination to be spread by process water. Levels of antimicrobial chemicals, along with pH and temperature, as appropriate, should be routinely monitored and recorded to ensure that they are maintained at appropriate levels.
- Special attention to water quality is required for common wash tank or flume systems and any recirculated water.

✓ **A CLOSER LOOK**

*Temperature Management*

*Optimal short-term distribution temperatures for fresh whole tomatoes a chilling-sensitive fruit, should be from 50o to 55oF (10o to 13oC) for ripened and mature-green tomatoes, respectively. Lower temperatures negatively affect the sensory quality of whole tomatoes after a few days, depending on stage of ripeness. Once sliced or diced, storage and distribution temperatures, typically at or below 41oF (5oC), prevent the growth of most food-borne bacterial pathogens (Listeria monocytogenes is one exception), but refrigeration does not eliminate contamination from the product should it be present. With fresh-cut products, lower temperatures to prevent or retard microbial growth overrides concerns for chilling injury.*

*The Conference for Food production in 2006 recommended that FDA amend the Food Code in Section 1-201.10 in the definition of Potentially Hazardous Food (Time/Temperature Control for Safety Food), to add "raw cut tomatoes" (such as sliced, diced, chopped, and pureed tomatoes) to (2)(a), and include this product group in the examples of foods that require time/temperature control for safety. If adopted by FDA and then adopted into local or state statutes, it would require that fresh-cut sliced or diced tomatoes be stored, distributed and displayed at or below 41F.*

## **KEY POINTS IN THE SUPPLY CHAIN FOR FRESH TOMATOES: FOODSERVICE OPERATOR**

A significant risk for cross-contamination in foodservice may arise from the slicing or dicing of fresh tomatoes on an unsanitized cutting surface in the kitchen. U.S. FDA 2005 Model Code Section 3-302.15 specifies that raw fruits and vegetables should be thoroughly washed in water to remove soil and other contaminations before being cut, combined with other ingredients, cooked, served or offered for human consumption.

- All finished product received from your distributor should be traceable. The traceability program should have the ability to trace all products all the way back to the field.
- A program should be in place that identifies all potential contamination risks and includes documented sanitation procedures that address all areas and equipment in the facility.

- Boxes of product should be placed on pallets to avoid direct contact with floors. Chemicals, trash, waste or odorous material must not be stored near product. Tomatoes must be stored at proper temperatures and humidity to prevent or delay microbial growth.
- Develop worker-training programs for fruit handling, preparation and processing to prevent bare-hand or gloved-hand contact of uncleaned fruit and cut fruit flesh, in sequence, by the same individual. It is recommended that such programs include the minimum requirements:
  - Wash hands thoroughly; wear gloves when handling fresh tomatoes.
  - Sanitize sink thoroughly with detergent, rinsing with clean water, then using a sanitation solution before washing tomatoes.
  - Fresh tomatoes with visible signs of decay or damage should not be used due to the possible increased risk of contamination.
  - Rinsing tomatoes in potable running water, agitate, and rinse.
  - Sanitize sink with clean water, sanitation solution, and a clean towel before final rinse of tomatoes.
  - Rinse tomatoes with clean water, shaking off excess, placing in a colander or perforated lexan to drain, prior to slicing.
  - Slice or cut on the day needed.
  - Use the right tool for the end product.
  - Use within 2-day shelf life unless recipe states to use immediately.
  - Cover, label/"use by" sticker and refrigerate.

✓ **A CLOSER LOOK**

*Temperature Management*

*Optimal short-term distribution temperatures for fresh whole tomatoes a chilling-sensitive fruit, should be from 50o to 55oF (10o to 13oC) for ripened and mature-green tomatoes, respectively. Lower temperatures negatively affect the sensory quality of whole tomatoes after a few days, depending on stage of ripeness. Once sliced or diced, storage and distribution temperatures, typically at or below 41oF (5oC), prevent the growth of most food-borne bacterial pathogens (Listeria monocytogenes is one exception), but refrigeration does not eliminate contamination from the product should it be present. With fresh-cut products, lower temperatures to prevent or retard microbial growth overrides concerns for chilling injury.*

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## **KEY POINTS IN THE SUPPLY CHAIN FOR FRESH TOMATOES: RETAIL STORES**

Fresh tomatoes are vulnerable to the growth of pathogenic micro-organisms which may be passed on from personnel in contact with the produce, and the adverse conditions which may be present in retailing (multiple handling by consumers/heat/light/outdoor conditions). It is important that good food handling practices and temperature control are adhered to at this stage in the food chain in order to continue the standards initiated by the grower, shipper, and repacker. The traceability program should have the ability to trace all products all the way back to the field.

- Boxes of product should be placed on pallets to avoid direct contact with floors. Chemicals, trash, waste or odorous material must not be stored near product. Tomatoes must be stored at proper temperatures and humidity to prevent or delay microbial growth.
- Optimal storage and display temperatures for fresh whole tomatoes, a chilling-sensitive fruit, should be no lower than 50o to 55oF (10o to 13oC). Lower temperatures negatively affect the sensory quality of whole tomatoes after a few days, depending on stage of ripeness.
- All display areas should be cleaned on a daily basis and any spillages occurring throughout the day should be immediately removed and the unit sanitized.
- Stock should be continually rotated based upon color, with higher color fruit being offered for sale prior to tomatoes of lesser ripeness.

- Tomatoes should be handled carefully when being mounted on non-refrigerated displays to avoid bruising and product damage.
- Produce should not be over-stacked in display units to avoid overheating (due to lack of air circulation), and produce bruising.
- Produce on display should be visually inspected on a regular basis throughout the day for damage, breakdown, physical contaminants and spillages:
  - Remove tomatoes with stem punctures from sale.
  - Any poor quality produce should be immediately removed from sale and be disposed of. The ability of food-borne pathogenic bacteria to grow on cut or punctured surfaces is of utmost concern.
  - Product culling should extend to packaged tomatoes. Packaged tomatoes present a problem, in that one poor quality tomato may affect the quality of the other tomatoes within the package.

## **KEY POINTS IN TOMATO HANDLING FOR CONSUMERS**

*Information from the Partnership for Food Safety Education - Produce Handling Education Campaign (<http://portal.fightbac.org/pfse/toolsyoucanuse/phec/>), recommends the following steps to help reduce the risk of food-borne illness from fresh produce.*

### Check

- Check to be sure that the fresh fruits and vegetables you buy are not bruised or damaged.
- Check that fresh cut fruits and vegetables like packaged salads and pre-cut melons are refrigerated at the store before buying. Do not buy fresh-cut items that are not refrigerated.

### Clean

- Wash hands with warm water and soap for at least 20 seconds before and after handling fresh fruits and vegetables.
- Clean all surfaces and utensils with hot water and soap, including cutting boards, counter tops, peelers and knives that will touch fresh fruits or vegetables before and after food preparation.
- Rinse fresh fruits and vegetables under running tap water, including those with skins and rinds that are not eaten.
- Rub firm-skin fruits and vegetables under running tap water or scrub with a clean vegetable brush while rinsing with running tap water.
- Dry fruits and vegetables with a clean cloth towel or paper towel.
- Never use detergent or bleach to wash fresh fruits or vegetables. These products are not intended for consumption.



### Separate

- When shopping, be sure fresh fruits and vegetables are separated from household chemicals and raw foods such as meat, poultry and seafood in your cart and in bags at checkout.
- Keep fresh fruits and vegetables separate from raw meat, poultry or seafood in your refrigerator.
- At the time of preparation, separate fresh fruits and vegetables from raw meat, poultry and seafood. Do not use the same cutting board without cleaning with hot water and soap before and after preparing fresh fruits and vegetables.
- Separate cut fruits and vegetables from raw unwashed fruits and vegetables.

### Cook

- Cook or throw away fruits or vegetables that have touched raw meat, poultry, seafood or their juices.
- Refrigerate all cut, peeled or cooked fresh fruits and vegetables within two hours.

### Throw Away

- Throw away fresh fruits and vegetables that have not been refrigerated within two hours of cutting, peeling or cooking.
- Remove and throw away bruised or damaged portions of fruits and vegetables when preparing to cook them or before eating them raw.
- Throw away any fruit or vegetable that will not be cooked if it has touched raw meat, poultry or seafood.

## GLOSSARY

*This glossary of definitions have been obtained from Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables, October 1998 ([www.foodsafety.gov/~dms/prodguid.html](http://www.foodsafety.gov/~dms/prodguid.html)) and the definitions describing risk are those adopted on an interim basis at the 22nd Session of the Codex Alimentarius Commission.*

**Agricultural Water:** refers to water used in the growing environment (for example, field, vineyard, or orchard) for agronomic reasons. It includes water used for irrigation, transpiration control (cooling), frost protection, or as a carrier for fertilizers and pesticides. Occasionally a more specific term may be used, such as “irrigation water.” Typical sources of agricultural water include flowing surface waters from rivers, streams, irrigation ditches, open canals, impoundments (such as ponds, reservoirs, and lakes), wells, and municipal supplies.

**Adequate:** means that which is needed to accomplish the intended purpose in keeping with good practice.

**Clean:** means that food or food-contact surfaces are washed and rinsed and are visually free of dust, dirt, food residues, and other debris.

**Control:** (a) to manage the conditions of an operation in order to be consistent with established criteria, and (b) to follow correct procedures and meet established criteria.

**Control Measure:** any action or activity that can be used to prevent, reduce, or eliminate a microbiological hazard.

**Facility:** the buildings and other physical structures used for, or in connection with, the harvesting, washing, sorting, storage, packaging, labeling, holding, or transport of fresh produce.

**Field Packed:** means that grading, sorting, sizing, packing, and palletizing are carried out in the field.

**Food-contact Surfaces:** are those surfaces that contact fresh produce and those surfaces from which drainage onto the produce or onto surfaces that contact the produce may occur during the normal course of operations. “Food-contact surfaces” includes equipment, such as containers and conveyor belts, which contact fresh produce, whether used in harvesting, post-harvesting, or packaging operations. It would not include tractors, forklifts, hand trucks, pallets, etc. that are used for handling or storing large quantities of contained or packed fresh produce and that do not come into actual contact with the food.

**Good Agricultural Practices:** refer to the guidelines set forth in the “Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables,” which was published by the U.S. Food and Drug Administration in 1998 ([www.foodsafety.gov/~dms/prodguid.html](http://www.foodsafety.gov/~dms/prodguid.html)).

cGMPs (current Good Manufacturing Practices): Current Good Manufacturing Practices in Manufacturing, Processing, Packing, or Holding Human Food (21 CFR 110).

Hazard: refers to a biological, chemical or physical agent in, or condition of, food with the potential to cause an adverse health effect.

Human Pathogen: means a microorganism capable of causing disease or injury to people. This is different from a plant pathogen that may cause disease to plants.

Microorganisms: include yeasts, molds, bacteria, protozoa, helminths (worms), and viruses. Occasionally, the term “microbe” or “microbial” is used instead of the term “microorganism.”

Microbial Hazard: means occurrence of a microorganism that has the potential to cause illness or injury.

Operator: means the person or persons who have day-to-day responsibility for the production, harvesting, washing, sorting, cooling, packaging, shipping, or transportation of fresh fruits and vegetables, and responsibility for management of all employees who are involved in each of these activities.

Packing Shed/Packinghouse: means a facility where raw agricultural commodities are washed, trimmed or sorted and packed in commercial containers e.g. cartons or totes.

Pest: refers to any animal or insect of public health importance including, but not limited to, birds, rodents, cockroaches, flies, and larvae that may carry pathogens that can contaminate food.

Raw Agricultural Commodity: any fruit or vegetable in its raw or natural state, including all fruits and vegetable that are washed, colored, or otherwise treated in the unpeeled natural form prior to marketing.

Risk: is a function of the probability of an adverse health effect and the severity of that effect, consequential to a hazard(s) in food.

Sanitize: means to treat clean produce by a process that is effective in destroying or substantially reducing the numbers of microorganisms of public health concern, as well as other undesirable microorganisms, without adversely affecting the quality of the product or its safety for the consumer.

Sanitize (food contact surfaces): means to adequately treat clean food-contact surfaces by a process that is effective in destroying or substantially reducing the numbers of microorganisms of public health concern, as well as other undesirable microorganisms, without adversely affecting the quality of the involved product or its safety for the consumer. It means the application of cumulative heat or chemicals on cleaned food-contact surfaces that, when evaluated for efficacy, is sufficient to reduce populations of representative microorganisms by 5 log or 99.999%.

Shed Packed: means grading, sorting, sizing, packing, and palletizing are carried out in a packing shed/packinghouse.

Value-Added or Fresh-Cut Produce: refers to fruits or vegetables that have been trimmed and/or peeled and/or cut into 100% usable product that is bagged or pre-packaged. These products are very often packed in protective plastic films and often these products are typically "ready-to-eat" food products, if they are labeled as "washed", "triple washed" or "ready-to-eat" as they have gone through a vigorous washing process before being packaged and sold. Products that are not labeled as such are raw agricultural commodities and should be considered raw agricultural commodities even if they packaged in a plastic over wrap or polyfilm.

## ACRONYMS

FDA: This acronym stands for the U.S. Food and Drug Administration.

GAP: This acronym stands for Good Agricultural Practices and synonymously refers to the “*Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*” published by the U.S. Food and Drug Administration. [www.foodsafety.gov/~dms/prodguid.html](http://www.foodsafety.gov/~dms/prodguid.html)

GMP: Good Manufacturing Practices in Manufacturing, Processing, Packing, or Holding Human Food (21 CFR 110) [www.access.gpo.gov/nara/cfr/waisidx\\_04/21cfr110\\_04.htm](http://www.access.gpo.gov/nara/cfr/waisidx_04/21cfr110_04.htm)

## **RESOURCES**

There are any number of resources available to help you build your own action plan. The following are a number of resources that you may wish to review:

Prevention of Post harvest Water Infiltration into Fresh Market Tomatoes: Food Safety and Spoilage Control Practices, 1998, University of California Cooperative Extension Vegetable Research and Information Web site, [http://vric.ucdavis.edu/issues/bulletinboard/tomato\\_microbial.pdf](http://vric.ucdavis.edu/issues/bulletinboard/tomato_microbial.pdf).

Water Disinfection: A Practical Approach to Calculating Values for Pre and Post Harvest Applications, 2001, University of California Cooperative Extension. Web site, [http://ucce.ucdavis.edu/freeform/UC\\_GAPs/documents/Water\\_Disinfection1893.pdf](http://ucce.ucdavis.edu/freeform/UC_GAPs/documents/Water_Disinfection1893.pdf)

Guidance for Industry: Food Producers, Processors, Transporters and Retailers: Food Security Preventive Measures Guidance, 2002, US FDA Center for Food Safety and Applied Nutrition Web site, <http://www.cfsan.fda.gov/~dms/secguid.html>.

Production and Post harvest Food Safety Begins on the Farm Brochure (English and Spanish), 2004, Cornell University Good Agricultural Practices Web site, <http://www.gaps.cornell.edu>.

On-Farm Food Safety Self Audit and Resource CD-ROM, order from University of California Cooperative Extension Good Agricultural Practices Web site, <http://ucgaps.ucdavis.edu/Information%5Favailable%5Fon%5Fa%5FCD/>

System-wide Biosecurity Food Security Guidance, Federal Register Notice of Availability, 2002, US FDA Center for Food Safety and Applied Nutrition Web site, <http://www.cfsan.fda.gov/~lrd/fr020109.html>.

## **ORGANIZATIONS AND GOVERNMENT AGENCIES**

A number of agencies can provide additional resources to growers and the supply chain.

Canadian Produce Marketing Association [www.cpma.ca](http://www.cpma.ca)

California Department of Health Service [www.dhs.ca.gov](http://www.dhs.ca.gov)

California Tomato Commission [www.tomato.org](http://www.tomato.org)

Food and Drug Administration [www.cfsan.fda.gov](http://www.cfsan.fda.gov)

Florida Tomato Committee [www.floridatomatoes.org](http://www.floridatomatoes.org)

Ontario Greenhouse Vegetable Growers [www.ontariogreenhouse.com](http://www.ontariogreenhouse.com)

Produce Marketing Association [www.pma.com](http://www.pma.com)

United Fresh Fruit and Vegetable Association [www.uffva.org](http://www.uffva.org)

## **OTHER RESOURCES**

U.S. Code of Federal Regulations (CFR) All  
[www.access.gpo.gov/nara/cfr/cfr-table-search.html#page1](http://www.access.gpo.gov/nara/cfr/cfr-table-search.html#page1)

U.S. Code of Federal Regulations (CFR) 21CFR 100-169 cGMPs and other Food Regulations  
[www.access.gpo.gov/nara/cfr/waisidx\\_04/21cfrv2\\_04.html](http://www.access.gpo.gov/nara/cfr/waisidx_04/21cfrv2_04.html)

U.S. Code of Federal Regulations (CFR) Food Labeling  
[www.access.gpo.gov/nara/cfr/waisidx\\_00/21cfr101\\_00.html](http://www.access.gpo.gov/nara/cfr/waisidx_00/21cfr101_00.html)

USDA, ARS Agriculture Handbook Number 66 The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks: Produce Food Safety  
[www.ba.ars.usda.gov/hb66/024foodsafety.pdf](http://www.ba.ars.usda.gov/hb66/024foodsafety.pdf)

## **APPENDIX**

### **USING OXIDATION REDUCTION POTENTIAL (ORP) FOR WATER DISINFECTION, MONITORING, CONTROL AND DOCUMENTATION**

TREVOR V. SUSLOW  
UNIVERSITY OF CALIFORNIA, DAVIS

Large volumes of water are commonly used during the post harvest handling and processing of minimally processed fruits and vegetables. Economic considerations and wastewater discharge regulations make water recirculation a common practice in the industry. Few practices have the capacity of water recirculation to increase the potential risk of food-borne illness by readily distributing a point source contaminant (one lot,

one bin, or even one plant) to non-contaminated produce. Disinfection of water is a critical step to minimize the potential transmission of pathogens from a water source to produce, among produce within a lot, and between lots over time. Water-borne microorganisms whether post harvest plant pathogens or agents of human illness can be rapidly acquired and taken up on plant surfaces. Natural plant surface contours, natural openings, harvest and trimming wounds, and handling injuries can serve as points of entry for microbes. Within these protected sites, microbes are unaffected by common post harvest water treatments such as chlorine, chlorine dioxide, ozone, peroxide, peroxyacetic acid, UV-irradiation and other approved treatments. It is essential, therefore, that the water used for washing, cooling, transporting, post harvest drenches, or other procedures be maintained in a condition suitable for the application. The standards for microbial quality of the water increase as product moves from the field to final processing. Accurate monitoring and recording of disinfection procedures is an important component of a sound post harvest quality and safety program during product cooling and processing.

Many fresh cut processors have adopted Oxidation-Reduction Potential (ORP), measured in millivolts (mV), as a primary approach to standardizing water disinfection parameters. Operationally much like a digital thermometer or pH probe, ORP sensors allow the easy monitoring and tracking of critical disinfectant levels in water systems. Coupled with pH sensors, more sophisticated systems use ORP sensors to provide automated “demand-based” injection of hypochlorite (or other approved oxidizing disinfectant) and acid, typically citric acid (See Cautions below).

In this section we provide a brief overview of the application of ORP monitoring to post harvest sanitation processes and describe the relationship of mV values to traditional standards relying on estimates of ppm (parts per million) of active disinfectant.

#### Benefits of ORP

Systems Oxidation-Reduction Potential (ORP) offers many advantages to “real time” monitoring and recording of water disinfection potential, a critical water quality parameter. Improvements in probe design and continuous analog recording (paper strip or revolving chart) or computer-linked data input are available. Record keeping can become a largely automated activity. Evaluation of process control by fluctuating water quality, product, and season, for example, are easier with the graphic outputs of available systems. Probes have been integrated to audible, visual and remote alarm systems to notify the operator of out of- range operation. Hand-held devices are affordable and essential back up to cross-reference the operation of an in-line probe. A primary advantage is that using ORP for water system monitoring provides the operator with a rapid and single-value assessment of the disinfection potential of water in a post harvest system. Research has shown that at an ORP value of 650 to 700mV, spoilage bacteria and bacteria such as *E. coli* and *Salmonella* are killed within a few seconds. Spoilage yeast and the more sensitive types of spore-forming fungi are also killed at this level after a contact time of a few minutes or less. Unfortunately, resistant spore-forming decay pathogens and human parasites, such as *Cryptosporidium*, are highly tolerant of chlorine, bromine, iodine and other weak oxidizers or metabolic poisons used for water disinfection. If hazard analysis identifies the potential for the presence of these parasites, treatment with peroxyacetic acid or ozonation of source water would be a suitable control measure. A combination of ORP and chemical indicator monitoring for ozone concentrations would be necessary.

A practical benefit in post harvest uses (such as transport flumes, bin drenchers, cooling flumes, hydro coolers, water-spray vacuum cooling, ice production, and ice injection) is that the measured ORP values accurately define the antimicrobial potential of the water for free-floating microbes. More conventional systems of measuring parts per million (ppm) with titration kits or paper test strips can give the same information but these should be combined with a measurement of water pH and reference to a table of hypochlorous acid (HOCl) availability. The water pH becomes an essential variable since the color-based test kits and paper strips detect hypochlorous acid and hypochlorite ion equally. Recent research in commercial and model post harvest water systems has shown that, if necessary, ORP limits can be relied on to determine microbial kill potential across a broad range of water quality.

It is important to point out that monitoring the build up of inorganic and organic particles remains important to prevent the excessive application of chlorine or other disinfectants to maintain a constant ORP set point. This makes sense from a cost, sensory quality, safety, and environmental responsibility perspective.

### Disadvantages of ORP Systems

Potential disadvantages of ORP based systems are largely operational issues related to the routine of equipment maintenance, calibration, and crosschecking of fixed position sensors. In practical terms, always have a back-up system of calibrated hand-held ORP probes and standard ppm kits. Sensors become fouled and need periodic cleaning and calibration. ORP probes may become temporarily saturated by over-injection of disinfectant. It can take several minutes or longer for the sensor to come back to equilibrium with the surrounding water, which can limit the response time.

It is important to use ORP as a “window” of operation rather than a fixed point. Sensors rarely establish a fixed point in a real system. The “bounce” observed in the sensor readout may be as much as 25 mV, especially in hand held units, depending on whether the probe is stationary or in movement. The size of the sensing surface will also influence the fluctuations in readings. Better sensors have a larger detection area. The best approach is to standardize a uniform method for taking measurements and set thresholds for a window of operation that achieves the microbial reduction objectives appropriate for the operation.

### ORP and Ozone

In a clean water system, using ORP to measure the dissolved ozone status works well. In our experience, however, the strong oxidizing power of ozone in complex (even moderate turbidity) systems can result in ORP values far below expected and even negative (reducing) values. In general, monitoring ozone with ORP at the generator source works well but measuring wash water becomes unreliable. Ozone detection kits are available and work well at the limit of approved concentrations for produce cooling and washing operations.

### ORP, pH, and ppm

The routine measurement of ORP in millivolts is not a linear relation at typical use rates in the produce industry. In general, a ten-fold increase in total or free chlorine concentrations will not result in a corresponding proportional increase in millivolts. This is predominantly a familiarity and comfort issue rather than one that impacts safety standards. For clean water, 3 to 5 ppm free chlorine will provide more than adequate microbial control for free floating bacteria in a very short contact time. This water quality will likely result in measurements of 650-700 mV ORP if the water pH is 6.5 to 7. Lowering the pH to 6.0 will raise the ORP as more hypochlorous acid becomes available. Raising the pH to 8.0 will lower the ORP value, as more hypochlorite ion is present. Maintaining constant pH but adding more chlorine will raise the ORP to a plateau of 900 to 950 mV, generally around 25 ppm free chlorine. Doubling the free chlorine will not result in a sizeable gain in ORP and may result in undesirable disinfection-by-products, product damage, and flavor tainting. Excessive chlorination, especially at pH below 6.8, will often create an uncomfortable and potentially unhealthy environment for workers. For most post harvest systems, it is unnecessary to operate above 800 mV, a set point used in primary wash and cooling systems where high concentrations of inorganic and organic matter, or harvest and processing wound exudates are released to the water.



## **HANDLING PROTOCOL FOR REPACKERS, RETAIL AND FOODSERVICE <sup>6</sup>**

An understanding of tomato handling protocol is essential for those in the distribution line in the development of individual guidance documents. The following information represents the generally accepted principles related to fruit quality in the handling of fresh tomatoes.

### Quality Indices

Standard tomato quality is primarily based on uniform shape and freedom from growth or handling defects. Size is not a factor of grade quality but may strongly influence commercial quality expectations.

Shape - well formed for type (round, globe, flattened globe, roma)

Color - Uniform color (orange-red to deep red; light yellow).

Appearance - Smooth and small blossom-end scar and stem-end scar. Absence of growth cracks, catfacing, zippering, sunscald, insect injury, and mechanical injury or bruises.

Firmness - Yields to firm hand pressure. Not soft and easily deformed due to an overripe condition.

U.S. grades for field and greenhouse tomatoes are No. 1, Combination, No. 2, (and No. 3 field only). Distinction among grades is based predominantly on external appearances, bruising and firmness.

### Optimum Temperature

Mature Green field tomatoes 12.5 - 15°C (55 - 60°F)

Light Red (USDA Color Stage 5) field tomatoes 10 - 12.5°C (50 - 55°F)

Firm-ripe (USDA Color Stage 6) field tomatoes 7 - 10°C (44 - 50°F) for 3-5 days

For greenhouse tomatoes, a storage temperature of 50° - 60°F (10.0° - 15.5°C) and a relative humidity of 90 – 95% is recommended for semi-ripe to fully ripe tomatoes.

Semi-ripe greenhouse tomatoes with 60 to 90% color can be held up to a week at 50°F/10.0°C. If held longer, they will probably not have a normal shelf life during retailing. Riper tomatoes will tolerate lower

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<sup>6</sup> <http://rics.ucdavis.edu/postharvest2/Produce/ProduceFacts/Veg/tomato.shtml>; amended to incorporate greenhouse standards.

temperatures, “firm-ripe” tomatoes can be held a few days at 50°F/10.0°C. Long holding of ripened tomatoes at low temperatures (40°F and below) results in loss of color, shelf life and firmness.

Mature-green tomatoes can be stored up to 14 days prior to ripening at 12.5°C (55°F) without significant reduction of sensory quality and color development. Decay is likely to increase following storage beyond two weeks, at this temperature. Typically 8-10 days of shelf life are attainable within the optimum temperature range after reaching the Firm-ripe stage. Short-term storage or transit temperatures below this range are used by some in the trade but will result in chilling injury after several days.

### Chilling Injury

Field tomatoes are chilling sensitive at temperatures below 10°C (50°F) if held for longer than 2 weeks or at 5°C (41°F) for longer than 6-8 days. Consequences of chilling injury are failure to ripen and develop full color and flavor, irregular (blotchy) color development, premature softening, surface pitting, browning of seeds, and increased decay (especially Black mold caused by *Alternaria* spp.). Chilling injury is cumulative and may be initiated in the field prior to harvest.

Chilling periods for fruit in storage and during transit have a cumulative effect on greenhouse tomatoes. Fruit chilled for a short period in storage can become susceptible to decay when held for only a short period at chilling temperature during marketing. Tomatoes should be kept out of cold, wet rooms because in addition to potential development of chilling injury, extended refrigeration damages the ability of the fruit to develop desirable fresh tomato flavor.

### Optimum Relative Humidity

90-95%; High relative humidity is essential to maximize post harvest quality and prevent water loss (desiccation). Extended periods of higher humidity or condensation may encourage the growth of stem-scar and surface molds.

### Rates of Respiration

Temperature  
ml CO<sub>2</sub>/ kg·hr Mature-green Ripening

5°C (41°F)  
3-4NR

10°C (50°F)  
6-9 7-8

15°C (59°F)  
8-14 12-15

20°C (68°F)  
14-20 12-22

25°C (77°F)  
18-26 15-26

To calculate heat production, multiply ml CO<sub>2</sub> / kg·hr by 440 to get BTU/ton/day or by 122 to get kcal/metric ton /day.

### Rates of Ethylene Production

1.2 - 1.5 $\mu$ l / kg-hr at 10°C (50°F)  
4.3 - 4.9 $\mu$ l / kg-hr at 20°C (68°F)

### Responses to Ethylene

Tomatoes are sensitive to exogenous ethylene and exposure of mature-green fruit to ethylene will initiate ripening. Ripening tomatoes produce ethylene at a moderate rate and co-storage or shipment with sensitive commodities, such as lettuce and cucumbers, should be avoided.

### Ripening Temperatures

18° -21°C (65 - 70°F); 90-95% R.H. for standard ripening 14° -16°C (57- 61°F) for slow ripening (i.e. in transit)

### Ripening of Mature Green Tomatoes

Faster ripening results from higher temperatures between 12.5 -25°C (55-77°F); 90-95% R.H.; 100 ppm ethylene. Good air circulation should be maintained to ensure temperature uniformity within the ripening room and to prevent the accumulation of CO<sub>2</sub>. CO<sub>2</sub> (above 1%) retards the action of ethylene in stimulating ripening.

The optimum ripening temperature to ensure sensory and nutritive quality is 20°C (68°F). Color development is optimal and retention of vitamin C content is highest at this ripening temperature. Tomatoes allowed to ripen off the vine above 25°C (77°F) will develop a more yellow and less red color and will be softer.

Ethylene treatment typically extends for 24-72 hours. A second treatment period may follow repacking if immature green fruit were included in the harvest.

### Responses to Controlled Atmospheres (CA)

Controlled atmosphere storage or shipping offer a moderate level of benefit. Low O<sub>2</sub> levels (3-5%) delay ripening and the development of surface and stem-scar molds without severely impacting sensory quality for most consumers. Storage times of up to 7 weeks have been reported for tomatoes using a combination of 4% O<sub>2</sub>, 2% CO<sub>2</sub>, and 5% CO. More typically, 3% O<sub>2</sub> and 0-3% CO<sub>2</sub> are used to maintain acceptable quality for up to 6 weeks prior to ripening. Elevated CO<sub>2</sub> above 3-5 % is not tolerated by most cultivars and will cause injury. Low O<sub>2</sub> (1%) will cause off-flavors, objectionable odors, and other condition defects, such as internal browning.

### Physiological Disorders

See Chilling injury.

Freezing Injury. Freezing injury will be initiated at -1°C (30°F), depending on the soluble solids content. Symptoms of freezing injury include a water soaked appearance, excessive softening, desiccated appearance of the locular gel.

### Pathological Disorders

Diseases are an important source of post harvest loss depending on season, region and handling practices. Commonly, decay or surface lesions result from the fungal pathogens *Alternaria* (Black Mold Rot), *Botrytis* (Gray Mold Rot), *Geotrichum* (Sour Rot), and *Rhizopus* (Hairy Rot). Bacterial Soft Rot caused by *Erwinia*

spp. can be a serious problem particularly if proper harvest and packinghouse sanitation is not used. Treatment with hot air or hot water immersion (55°C for 0.5 - 1.0 min.) has been effective in preventing surface mold but has not been used extensively for commercial treatments.

#### Special Considerations

Rapid cooling soon after harvest is essential for optimal post harvest keeping quality. The precooling endpoint is typically 12.5°C (55°F). Forced-air cooling is the most effective practice but room cooling is more common.