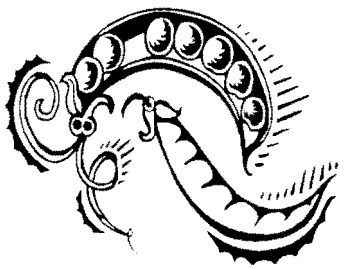
CHAPTER 15



FOOD SAFETY DURING PROCESSING

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

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

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

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

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

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

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

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

Monitor raw material suppliers for adherence to Good Agricultural Practices.

Keep processing facility grounds clean and free from clutter.

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

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

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

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

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

Use only potable (safe to drink) water.

Monitor water quality regularly.

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

Dos and Don'ts continued:

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

Toilets facilities should be segregated from the processing area.

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

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

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

GOOD MANUFACTURING PRACTICES (GMP's)

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

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

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

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

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

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

SANITATION PROCEDURES

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

A Master Sanitation Schedule

Monitoring Program

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

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

Cleaning and sanitizing involves five basic steps:

Physical Debris Removal

Rinse

Detergent / Mild Abrasion

Post Rinse

Sanitizing

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

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

SOP's identify the following:

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

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

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

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

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

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

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

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

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

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

Quaternary Ammonia Compounds: Non Corrosive, Heat Stable, Expensive

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

MONITORING

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

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

Petri Contact Plates

Surface Swabbing

Biolumenesce

Petri Contact Plates

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

Surface Swabbing

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

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

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

Bioluminescence

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

Microbiological Test Suppliers

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

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

HACCP

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

Model HACCP Plan for Dried Apple Slices

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

Ingredients: Apple

Potential Microbiological Hazards to be Monitored:

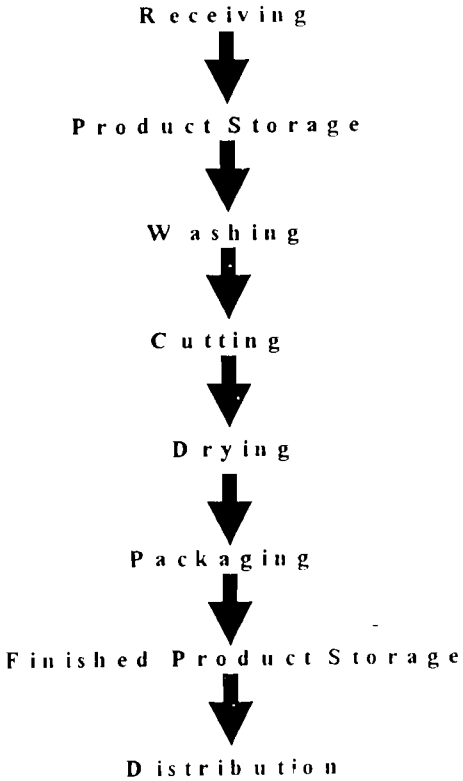
Potential Human Pathogens: Pathogenic *E. coli*, *Salmonella*, *Shigella*, and foodborne viruses.

Sanitation Monitoring Organisms:

E. coli, aerobic plate count

Critical Control Points:

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



Flow Diagram for a fruit or vegetable drying operation.

Model HACCP Plan for Dried Apple Slices:

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

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