

Good Management Practices for Safe Growing, Harvesting, and Packing of Fresh Mushrooms

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INTRODUCTION

Good Management Practices for Safe Growing, Harvesting, and Packing of Fresh Mushrooms is intended to identify a broad range of potential microbial, chemical, and physical hazards that may occur during growing, packing, and distribution of mushroom products.

The scientific basis for identification and prevention of these hazards is not complete. However, the guidelines issued here are based on established sanitation and hygiene principles for use in food processing and agricultural packing environments. Food safety control measures presented in this document were drawn from the following documents:

- “Current Good Manufacturing Practice in Manufacturing, Packing, or Holding Human Food (CFR 21 Part 110)”
- “Guidance for Industry -- Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables”, FDA
- “Codex Alimentarius Food Hygiene – Basic Texts”, WHO/FAO

Because of the diversity of mushroom processes and products, the potential hazards and control methods identified here may not apply to all mushroom operations. Individual growers, packers, and distributors should seek to identify additional potential hazards and control measures in their own operations as a complement to the broad principles presented in this guide.

This guide is based on the following basic principles for maintaining the safety of fresh mushroom products:

Principle 1. Prevention of food safety hazards is favored over reliance on corrective actions once a problem has occurred.

Principle 2. To minimize food safety hazards in mushroom products, growers, packers, and distributors should use good management practices in those areas over which they have control.

Principle 3. Mushrooms can become contaminated at any point between growing and receipt by the customer.

Principle 4. Water has the potential to be a source of contamination during mushroom growing and subsequent handling.

Principle 5. The use of animal manures in substrate preparation should be managed carefully to minimize the potential for microbial contamination of mushrooms.

Principle 6. Worker hygiene and sanitation practices during growing, harvesting, and handling play a critical role in minimizing the potential for microbial contamination of mushrooms.

Principle 7. Growers and packers should consider themselves suppliers of a fresh food that may not be cooked and, therefore, should follow all applicable laws and regulations designed to ensure safe food products.

Principle 8. Accountability at all levels of the agricultural environment (growing, packing distribution, and transportation operations) is an important component in a successful food safety program. There must be qualified personnel and effective monitoring to ensure that all elements of the program function correctly and to help track products back through the distribution channels to the producer.

Principle 9. Control of food safety hazards in mushroom growing, harvesting, packing, and distribution operations is best achieved through a systematic, preventative, and well documented food safety program based on established Hazards Analysis Critical Control Point (HACCP) principles.

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This guide is divided into the following food safety hazard control areas:

- 1 Facilities design and plant layout
- 2 Equipment design and maintenance
- 3 Receiving and storage of raw materials
- 4 Water quality
- 5 Cleaning and Sanitation
- 6 Pest control
- 7 Worker hygiene and sanitary facilities
- 8 Transportation
- 9 Product traceback and recall
- 10 Training
- 11 Process control

1. FACILITIES DESIGN AND PLANT LAYOUT

Buildings and facilities where mushroom substrate is prepared, and where mushrooms are grown, harvested, packed, and transported should be designed and maintained to permit sanitary operations and to protect against cross contamination.

Potential hazards:

1. Cross contamination caused by inadequate control of worker and equipment traffic.
2. Inadequate separation of raw manure and unpasteurized substrate from mushroom cropping, packing, and storage areas.
3. Contamination of mushrooms caused by inadequate design and maintenance of buildings and grounds.

Preventive or corrective measures:

1. The design of the facilities should permit adequate protection from cross-contamination.

- Areas where raw animal manure, unpasteurized substrate which contains raw manure, or other potentially hazardous materials are processed, stored, or transported should be clearly separated from areas where mushrooms are grown, harvested, and packed. Raw materials should not be received in mushroom loading and shipping areas.
- Traffic patterns for employees and equipment should be established to avoid contamination of pasteurized substrate, casing materials, and mushrooms with raw manure and unpasteurized substrate. Workers and equipment exclusive to the phase I substrate preparation process should be confined to that area so that they do not constitute a source of contamination in areas where mushrooms are grown, harvested, packed, and stored.
- Entrances and exits to and from areas where mushrooms are handled should be kept to a minimum. In cases where workers, visitors, or equipment must move from where substrate is prepared to areas where mushrooms are grown, packed, stored or transported, adequate measures to clean and disinfect footwear, hands, and equipment should be taken.

2. The grounds within mushroom growing and packing operations should be properly maintained to prevent contamination of mushrooms.

- Tall weeds or grass within the immediate vicinity of the plant buildings or structures may attract and provide breeding places for pests that may spread pathogens and therefore should be regularly cut. Areas where substrate ingredients are stored should be regularly checked for pests and signs of pest infestation.
- The grounds should be adequately drained to prevent pests from breeding and to prevent accumulation of contaminated water in growing and packing areas. Good drainage in phase I areas is essential to direct seepage of manure or substrate away from downstream operations. Roads, yards, and parking lots should be maintained to prevent the spread of dust into areas where mushrooms may be exposed.
- Litter, trash, and inedible waste should be stored in properly covered containers and removed regularly. Trash containers should be stored on a level, paved, and well-drained surface.

3. Plant buildings and structures should be appropriately designed and maintained to facilitate maintenance and sanitary operations.

- Buildings where mushrooms are grown, packed, or stored should not be a source of microbial, chemical or physical hazards. Buildings should be constructed and maintained so that floors, walls, and ceilings can be adequately cleaned and kept clean and in good repair.

- In rooms that are not steam pasteurized, floors should be constructed of washable, nonporous materials and adequately sloped to allow drainage. Removable grates or plugs on drains should be installed to protect against pests.
- Walls and ceilings where mushrooms are handled should be made of light-colored, washable, and nonporous materials or be steam pasteurized. Exposed piping, wiring, and drainage lines should allow for adequate cleaning of walls and ceilings.
- Doors should be adequately constructed with spaces between the jam and the door sealed properly. Exterior doors in packing facilities should be self-closing or have an insect screen or air curtain installed.
- Drip or condensate from fixtures, ducts and pipes in packing facilities should not be allowed to contact food, food-contact surfaces, or food-packaging materials.
- Aisles or working spaces between equipment and walls should be adequately unobstructed and of adequate width to permit employees to perform their duties and to protect against contaminating food or food-contact surfaces with clothing or personal contact. Sufficient space for placement of equipment and adequate storage space for mushrooms and materials used to grow them should be provided.
- Areas where mushrooms are grown, packed, stored, or transported should be properly ventilated to control ambient temperature and to prevent excessive humidity that may cause condensate to form. Ventilation systems should be designed so that air does not flow from potentially contaminated areas to clean areas and should be adequately cleaned and maintained.
- Adequate lighting should be provided in hand-washing areas, dressing and locker rooms, and toilet rooms and in all areas where mushrooms are harvested, packed, stored, and transported.
- Safety-type light bulbs that prevent contamination of mushrooms with glass should be used and regularly cleaned.

2. EQUIPMENT DESIGN AND MAINTENANCE

Equipment used in all operations should be designed and maintained to allow adequate cleaning and sanitizing as necessary and to prevent contamination with microbial, chemical, and physical hazards. Regular maintenance and calibration of equipment should be assured by establishing a preventive maintenance program.

Potential hazards:

1. Inadequate design and maintenance of equipment leading to contamination of mushrooms.

2. Improperly maintained and calibrated monitoring equipment that causes deviations from a process designed to produce a safe product.

Preventive or corrective measures:

1. Equipment should be appropriately designed and utilized to ensure sanitary operations.

- Equipment for moving, mixing, or otherwise handling unpasteurized substrate should not be used for handling pasteurized substrate, casing materials, or mushrooms and should be cleaned as frequently as necessary to protect against contamination of the premises.
- Equipment used to convey, clean, slice, pack, or otherwise come into contact with mushrooms should be designed to avoid inaccessible areas that may trap water and debris and should be capable of easy disassembly and cleaning. Mushrooms should be adequately protected from loose belts, nuts, rivets, washers, and other fasteners. Equipment should be maintained in good repair to function as intended and to facilitate all sanitation procedures.
- Cleaned and sanitized portable equipment and utensils with food-contact surfaces should be stored in a location and manner that protects food-contact surfaces from contamination.

2. Equipment should be regularly maintained to ensure that it is used as intended

- Refrigeration and heating units, mixers, conveyers, compressors, fans, trucks, forklifts, and any other equipment used in growing, packing, distribution, and transportation of mushrooms should be kept in proper working order.
- A regularly scheduled preventative maintenance program should be established to prevent equipment failure.

3. Equipment used for process monitoring and recording should be regularly maintained and calibrated.

- Temperature recording devices, timers, alarms, data loggers, and any other equipment used to monitor and record process data should be regularly maintained and calibrated.

3. RECEIVING AND STORAGE OF MATERIALS

Materials received from outside suppliers include substrate ingredients, casing material, spawn, cleaners, sanitizers, pesticides, fungicides, disinfectants, and packaging materials. Materials used in growing, harvesting, packing, and storing mushrooms may become a source of microbial, chemical, or physical contamination. Monitoring and verification of the quality of materials received from outside suppliers are

essential tools to assure the safety of mushroom products. Suppliers should be considered as active partners in producing safe products.

The type of monitoring and the degree of compliance required may be based on the step at which the materials are used in the process. Specification for raw materials used to prepare substrate may be less stringent compared to other raw materials because contaminants are more likely to be destroyed by subsequent composting and pasteurization steps. However, suppliers who provide materials that are not treated to reduce hazards and that may potentially come into contact with mushrooms should be more tightly controlled.

Proper storage practices prevent contamination of mushrooms with pathogens or hazardous chemicals.

Potential hazards:

1. Excessive levels of pathogens, pesticides, or hazardous chemicals contained in purchased substrate ingredients.
2. Use of unapproved cleaners, sanitizers, pesticides, fungicides, disinfectants, and packaging materials.
3. Contamination of materials during storage.

Preventive or corrective measures:

1. **Controls for potential microbiological, chemical, and physical hazards in all materials received should be established by implementing a vendor approval and certification program.**
 - Raw materials should not be accepted if they are known to contain pathogens, pesticides, or toxic, decomposed or extraneous substances which would not be reduced to acceptable levels by normal sorting and/or processing. Raw materials or ingredients should, where appropriate, be inspected and sorted before processing. Where necessary, laboratory tests should be made to establish their fitness for use. Only raw materials established for use by scientific principles should be used.
 - New or infrequent suppliers or those with inconsistent records for meeting minimum standards should submit to periodic inspections or supply testing results to verify compliance with standards. Suppliers who have repeatedly demonstrated ability to meet product specifications may not need to be periodically tested but should at a minimum submit letters of assurance or certificates of analysis to verify compliance. Appropriate records should be kept to monitor the performance of suppliers and if necessary for traceback of sources of contamination.

- Only properly labeled pesticides, fungicides, cleaners, sanitizers, and disinfectants that are safe under the conditions of use and are approved for use in mushroom growing and packing operations should be purchased. Packaging materials should be made of approved food grade materials. All relevant Federal, State, and local government regulations for the application, use, or holding of these products should be followed. Records indicating date of receipt, carrier, lot number, amount, and temperature if appropriate should be maintained.

2. Materials should be stored under conditions that will protect mushrooms from microbial, chemical, and physical contamination.

- Raw manure and unpasteurized substrate should be stored as far away as possible from areas where mushrooms are grown, harvested, packed, and stored.
- Storage areas should be either protected from rainfall by covering the materials or the runoff should be collected using barriers or physical containment measures such as concrete blocks, soil berms, pits, or lagoons.
- Pesticides, fungicides, cleaners, sanitizers, and other potentially hazardous chemicals should be stored in designated areas that will protect mushrooms, food contact surfaces, and food packaging materials from chemical contamination.
- Containers used for harvesting and packaging materials should be stored in a manner that protects them from contamination by pests, dirt, and water condensing from overhead equipment and structures. Food contact containers that are stored outside the packing facility or are not clean when received, should be cleaned and sanitized before use.

4. WATER QUALITY

Water may be used for substrate preparation; facilities and equipment cleaning, rinsing, and sanitizing; applications of pesticides, fungicides, and irrigation chemicals; and product washing, disinfection, and rinsing.

Water of inadequate quality has the potential to be a direct source of contamination and a vehicle for spreading localized contamination during substrate preparation, growing, and processing. Wherever water comes in contact with mushrooms, its quality dictates the potential for contamination.

Growers and packers must ensure that water used in all mushroom growing and packing operations is sufficiently free of hazardous microorganisms and chemicals.

Potential hazards:

1. Contamination of water with human pathogens.

2. Infection of workers with human pathogens contained in contaminated water who then may contaminate mushrooms during growing, harvesting, and handling.
3. Contamination of water with hazardous chemicals such as pesticides, fertilizers, heavy metals, or other potentially harmful compounds.

Preventive or corrective measures:

1. Water that contacts mushrooms or food-contact surfaces should be safe and sanitary.

- Water quality needs may vary depending on whether it is used in substrate preparation or during growing and processing. However, water that directly contacts mushrooms or surfaces that come into contact with mushrooms should meet federal drinking water standards.
- The quality of surface water varies considerably, and therefore should not be used in mushroom growing and processing operations unless it is adequately treated to eliminate chemical or microbiological contamination. Ground water that is influenced by surface water, such as older wells with cracked casings, may also be vulnerable to contamination and should be regularly monitored.
- Running water at a suitable temperature, and under pressure as needed, should be provided in all areas where required for processing operations, for the cleaning of equipment, utensils, and food-packaging materials or for employee sanitary facilities.

2. Perform periodic monitoring of water quality.

- Growers and processors should test their water supply for microbial contamination on a periodic basis, using standard indicators of fecal pollution.
- Municipal water quality should be verified by obtaining a certificate of analysis from the local water authority. The quality of well water is less certain depending on the condition of the well and the potential for ground water contamination. Therefore, its quality should be monitored on a more frequent basis.

3. Treat water with antimicrobial chemicals as necessary to prevent microbial contamination.

- Addition of antimicrobial chemicals may be necessary to raise the quality of water to an acceptable level. All chemical substances that disinfect wash water and contact food must be used in accordance with FDA and EPA regulations. Operators should carefully read antimicrobial chemical labels, regulations, and other relevant information. Operators should follow manufacturers' directions for correct mixing of antimicrobial chemicals to minimize the occurrence of safety hazards.

- The concentration of antimicrobial chemicals in treated water should be routinely monitored and recorded to ensure that they are maintained at appropriate concentrations.

5. CLEANING AND SANITATION

An effective cleaning and sanitation program ensures that all grounds, buildings, structures, and equipment are appropriately clean for their intended use. It is important that growers and packers regularly clean and sanitize as appropriate to prevent buildup of microorganisms and pests that may contaminate products.

Potential hazards:

1. Contamination of mushrooms from improperly cleaned and sanitized food contact surfaces
2. Buildings and grounds that are not regularly cleaned may provide favorable conditions for pests to live.

Preventive or corrective measures:

1. **Establish a master cleaning schedule for the buildings, grounds, storage areas, equipment, and utensils.**
 - A regularly scheduled and “as needed” program should be implemented that ensures that all parts of the operation are appropriately clean and sanitary.
 - The program should specify what areas or equipment are cleaned and/or sanitized, the person responsible, the method and frequency of cleaning, and verification procedures.
2. **Cleaning and sanitizing of food contact surfaces should be performed with approved and effective compounds as frequently as is necessary to prevent contamination of mushrooms.**
 - Cleaning should remove food residues and dirt which may be a source of contamination.
 - When necessary to protect against contamination, food contact surfaces should be cleaned and then sanitized before use and after any interruption during which the surfaces may have become contaminated.
 - Clean packing areas at end of each day and, as necessary, clean and sanitize the washing, grading, sorting, and packing lines to reduce the potential for microbial contamination.

3. **Cleaning and sanitizing procedures should be regularly monitored for effectiveness.**
 - Pre-operational inspections, audits, or microbiological sampling of the environment or of food contact surfaces should be conducted to ensure that cleaning and sanitizing procedures are effective.

6. PEST CONTROL

All animals, including rats, mice, birds, reptiles, and insects, are potential sources of contamination of mushrooms because they harbor, or could be a vector for human pathogens. An effective pest control program is, therefore, an essential component of a food safety plan.

Potential hazards:

1. Microbial contamination of mushrooms, food-contact surfaces, and packaging materials by insect vectors.
2. Chemical contamination of mushrooms, food-contact surfaces, and packaging materials through incorrect application of pesticides.

Preventive or corrective measures:

1. **Establish a preventive pest control program.**
 - Applications of approved pesticides should be undertaken by or under the supervision of a licensed pest control applicator.
 - Preventative measures to prevent entry and reduce breeding places for pests include keeping grounds clear of waste, litter, and improperly stored garbage, keeping all grasses cut, removing unused equipment, installing screening where necessary, and maintaining adequate surface drainage.
 - Use only glue boards or mechanical traps with non-toxic bait in areas where mushrooms are grown or handled unless the bait is of sufficient size to be prevented from mixing with the product. Remove dead or trapped birds, insects, rodents, and other pests promptly to ensure clean and sanitary facilities and to avoid attracting additional pests and clean surfaces soiled by pests.
 - Regular and frequent monitoring of affected and treated areas should be conducted to accurately assess the program's effectiveness.
 - Maintain a pest control log that includes dates of inspection, inspection report, and steps taken to eliminate any problems.

7. WORKER HYGIENE AND SANITARY FACILITIES

A major cause of food borne illness is unsanitary practices by people who handle food. Workers can unintentionally contaminate mushrooms, water supplies, and other workers, if they do not understand and follow basic hygienic principles. It is essential, therefore, that workers who harvest or otherwise handle mushrooms understand that they have a personal responsibility to practice proper hygiene.

It is the responsibility of management to supply workers with adequate sanitary facilities, to see that they are properly used, and to educate workers on the importance of good hygiene practices.

Potential hazards:

1. Microbial contamination of mushrooms during harvesting and handling by workers who have pathogenic microorganisms on the surface of their hands.
2. Microbial contamination of mushrooms during harvesting and handling by workers who have been infected with human pathogens and have a communicable disease.
3. Contamination of mushrooms with harvesting tools or by personal items such as cigarettes, jewelry, pens, glass, or hair.

Preventive or corrective measures:

1. **Workers who handle fresh mushrooms should practice good personal hygiene**
 - Workers who harvest or otherwise handle mushrooms or are in contact with food-contact surfaces, and food-packaging materials should maintain adequate personal cleanliness in order to protect against contamination.
 - Employees who handle mushrooms should wash hands thoroughly with soap before starting work or after using toilet facilities, eating, drinking, smoking, or at any time when their hands may have become soiled or contaminated.
 - Workers who are not appropriately clean or have open lesions, boils, sores, or infected wounds should not come in contact with mushrooms, food-contact surfaces, or food-packaging materials.
 - All unsecured jewelry and other personal objects that might fall into mushrooms, equipment, or containers, should be removed or covered effectively. Hand jewelry that cannot be removed should be covered by sanitary gloves.
 - Workers who harvest or otherwise handle mushrooms should wear hairnets, headbands, caps, beard covers, or other effective hair restraints and wear clean outer garments during harvesting and handling operations.
 - Eating food, chewing gum, drinking beverages, or using tobacco is not allowed in growing and packing areas.

- Personal items such as pens, pencils, smoking materials, or thermometers should not be carried in shirt pockets when employees are in mushroom harvesting and handling areas.
- Glass or brittle plastics should not be brought into these areas at any time unless absolutely necessary to maintain operations.
- Clothing or other personal belongings should be stored in areas other than where mushrooms are grown or packed.
- Workers should be adequately trained in proper food handling techniques and food-protection principles and should be informed of the danger of poor personal hygiene and unsanitary practices.

2. Management should provide workers with adequate sanitary facilities.

- Each operation where mushrooms are harvested or otherwise handled should provide its employees with a sufficient number of readily accessible and well furnished toilet facilities that are maintained in a sanitary condition and kept in good repair at all times.
- Toilet facilities in areas where mushrooms are grown, packed, or stored should have self-closing doors or adequate ventilation to prevent airborne contamination. Rubbish should be disposed of regularly to minimize the potential for attracting pests.
- Handwashing stations should be equipped with running water, a basin, soap, and, when appropriate, a waste container. Common, or shared, towels should not be used. If hand-sanitizing solutions are used, they should be maintained by regularly checking solution strength.
- Management should not assume that workers know how to wash their hands properly and should train proper handwashing techniques.
- Single-service disposable gloves can be an important and effective hygienic practice in combination with handwashing in some circumstances. If gloves are used, they should be used properly and do not become another vehicle for spreading pathogens. Workers should replace gloves if they handle materials that may be contaminated. The use of gloves in no way lessens the need or importance of handwashing and proper hygienic practices.
- Management should establish and maintain a glass and brittle plastics policy stating that these materials should not be brought into areas where mushrooms are harvested and handled unless absolutely necessary. Any essential glass or brittle plastic that must be brought into these areas should be checked on a regular basis to ensure that no breakage has occurred.
- Inspectors, buyers, and other non-company persons who visit areas where mushrooms are grown and handled should comply with the above hygienic practices.
- Management is responsible for assuring that workers are following good hygiene practices. Supervisors should have sufficient knowledge of sanitation and hygiene procedures to assess worker compliance. Food handlers and supervisors should receive appropriate training in proper food

handling techniques and food-protection principles and should be informed of the danger of poor personal hygiene and unsanitary practices.

3. Supervisors should become familiar with typical signs and symptoms of infectious diseases.

- Workers with diarrheal disease and symptoms of other infectious diseases should be excluded from harvesting or otherwise handling mushrooms.
- Supervisors should be familiar with the symptoms of infectious diseases so that if symptoms are evident, the supervisor can take appropriate steps.
- Employees should be instructed to report any active case of illness to their supervisor before beginning work.

8. TRANSPORTATION

Transportation of finished products is usually the last step at which the grower or packer can control the safety of mushrooms. Both internal and contracted shippers must be aware of their role in ensuring delivery of safe products to the consumer.

Potential hazards:

1. Contamination from other foods and food contact surfaces during loading, unloading, storage, and transportation operations.
2. Growth of microorganisms if proper temperatures are not maintained during shipping.

Preventive or corrective measures:

1. **Inspect trucks or transport cartons for cleanliness, odors, obvious dirt or debris before beginning the loading process.**
 - Operators should be aware of prior loads carried in a transport vehicle and take this information into consideration when determining use of a vehicle. Trucks that were recently used to transport animals, animal products, or other materials that may contaminate mushrooms would increase the risk of contaminating mushrooms if the trucks were not cleaned before loading produce.
2. **Load mushrooms in trucks or transport cartons in a manner that will minimize damage.**
 - Mushroom containers should be carefully loaded into trucks in a manner that will minimize damage to the product. When container integrity is compromised, there is a greater chance for product contamination.

- Containers should also be loaded so as to allow proper refrigerated air circulation.

3. Maintain proper temperatures to help ensure both the quality and safety of fresh mushrooms.

- Operators should work with transporters to ensure adequate control of transport temperatures from the loading dock to the receiving dock. Transporters should be aware of temperature requirements for fresh mushrooms.

9. PRODUCT RECALL AND TRACEBACK

The ability to trace the distribution history of food items from grower to consumer will not prevent a foodborne illness outbreak from occurring. However, being able to quickly trace a food back to its source can limit the public health and economic impacts of an outbreak. Because fresh mushrooms have a relatively short shelf life and are consumed within a short time after harvest, rapid recall procedures are essential.

Effective traceback procedures can quickly identify a hazardous product and limit the amount of product that must be recalled. Written procedures for product identification, tracking, and recall are therefore important to protect product quality and safety.

Potential hazards:

1. Insufficient or inaccurate labeling of mushrooms containers and packages that prevents or delays traceback of mushroom products to their source of production or processing and potentially increase the impact of a foodborne disease outbreak.
2. An inadequate written plan to respond to a foodborne disease outbreak that delays implementation of a recall and thus increases the impact of a foodborne disease outbreak.

Preventive or corrective measures:

1. **Establish and maintain procedures for labeling individual containers and packages of mushrooms that will enable tracking of the product back to the grower.**

- The label on containers used for storage or transfer of mushrooms within the company should contain, at a minimum, the following information:
 - name of the company
 - name of the product
 - the individual or department that has handled the product
 - the lot number traceable to location and date of harvest
- The label on all packages for wholesale or retail sale should include all items required by federal, state, and local regulations including:
 - the name
 - street address
 - city, state, zip code
 - a product code that enables traceback to the point at which the mushrooms were grown.

2. Develop a recall strategy.

- Written procedures should be developed in the event that a mushroom grower or processor wishes to remove a product from the marketplace. A market withdrawal should be initiated if mushrooms are found to be contaminated.
- Those who purchased the affected product should immediately be provided with the following information:
 - the identity of the product
 - the reason for removal
 - an estimate of the extent of the risk
 - the quantity of product to be recalled
 - when it was shipped

Arrangements should then be made to return the product or dispose of it properly.

10. TRAINING AND EDUCATION

All employees, including supervisors, full time, part time, and temporary personnel, who come into contact with food should have a working knowledge of basic sanitation and hygiene principles. The level of understanding needed will vary as determined by the type of operation, the task, and the assigned responsibilities.

Potential hazards:

1. Workers who harvest or otherwise handle mushrooms and are unaware of the importance of good hygiene and sanitary practices can be a source of contamination.
2. Procedures designed to produce a safe product may not be carried out correctly when workers are not properly trained to carry out their assigned responsibilities.

Preventive or corrective measures:

- 1. All personnel should be trained to understand their role and responsibility in protecting food from microbial, chemical, and physical hazards.**
 - Employees who harvest or otherwise handle mushrooms should be trained in basic food hygiene and sanitation concepts appropriate to their tasks.
 - Employees who handle hazardous chemicals should be trained in safe handling techniques.
 - When a formalized training program is not practical, such as for part time and seasonal personnel, supervisors should verbally instruct and demonstrate to newly hired workers proper health and hygiene practices, such as proper handwashing techniques.
- 2. Employees should be properly trained in the fundamentals of mushroom growing and processing technology.**
 - Management and workers, appropriate to their levels of responsibility, should regularly attend workshops, shortcourses, and other educational opportunities to maintain technical proficiency in all mushroom operations.

11. PROCESS CONTROL

Mushroom growers and packers should thoroughly understand the potential hazards associated with each step in their process. Identification of hazards and methods to control them is best achieved through a systematic and preventative food safety program based on established HACCP (Hazard Analysis Critical Control Point) principles.

It is essential that all procedures designed to minimize the occurrence of microbial, chemical, and physical hazards in mushroom growing and packing operations are strictly followed. The frequency and degree to which preventive and monitoring procedures should take place will vary depending on the probability that the hazard will occur and the severity of the outcome.

Potential hazards:

1. The risk of producing contaminated mushrooms may increase to an unacceptable level if the heat treatment achieved during Phase I substrate preparation and Phase II pasteurization is not sufficient to eliminate pathogens,
2. Incorrect measuring, mixing, and application of pesticides, fungicides, and other chemicals that contact mushrooms may result in contamination of mushrooms.
3. Slicing blades may crack or chip and contaminate mushrooms with metal fragments.

4. Anaerobic conditions favorable for the growth of pathogens may occur when mushrooms are packed in unventilated packages.
5. If pathogens are present on harvested mushrooms, growth may occur if refrigerator temperatures exceed 40°F.

Preventive or corrective measures:

1. Monitor Phase I substrate and Phase II pasteurization temperatures

- The temperatures achieved during production of high quality Phase I substrate and during Phase II pasteurization are above that which is required to kill mesophilic human pathogens. In the event that lethal temperatures are not achieved, corrective actions should be implemented to control the process.

2. When insecticides or fungicides are directly applied to mushrooms, adequate control should be maintained over the frequency and amount applied.

- Pesticides should be prepared in accordance with the manufacture's instructions.
- Applicators should document that correct procedures regarding dilution and application occur.

3. Regularly check slicing blades for signs of damage and monitor product for evidence of metal contamination.

- Regular maintenance and inspection of slicer blades during processing is essential but may not be sufficient to prevent the occurrence of metal in the product.
- Continuous monitoring of metal in packaged mushrooms is best achieved using an online metal detector.

4. The presence of at least two 1/8 inch film ventilation holes per package should be adequately monitored.

- Conditions favorable for growth of pathogens may occur when oxygen levels are low and the product is temperature abused. Sufficient control may be achieved by inspecting packaging film for compliance as it is received or after the film is applied to the product and by maintaining control of product temperature.

5. Refrigerator temperatures should be adequately monitored and documented to assure maintenance of temperatures at or below 40°F.

- Maintenance and calibration of refrigeration units is essential, however, pulp and/or air temperatures should be regularly logged and corrective actions should be taken if a deviation occurs.

References:

- Current Good Manufacturing Practice in Manufacturing, Packing, or Holding Human Food, Code of Federal Regulations 21 Part 110.
- Guidance for Industry -- Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables, 1998. U.S. Department of Health and Human Services, Food and Drug Administration, Center for Food Safety and Applied Nutrition.
- "Food Hygiene – Basic Texts", 1997. Codex Alimentarius Commission, FAO/WHO.
- Principles of Food Processing and Sanitation. 1993. A.M. Katsuyama ed. Food Processors Institute, National Food Processors Association.
- Principles of Food Sanitation.1999. N.G. Marriott. Aspen Publications.
- Food Safety Guidelines for the Fresh-cut Produce Industry. 1996. Zagory, D. and Hurst, W.C. eds. International Fresh-cut Produce Association.