



# Good Agricultural Practices: What Growers Should Know



**College of Agriculture and Home Economics**  
Cooperative Extension Service • Agricultural Experiment Station

In November 1998, the New Mexico Chile Task Force was formed to identify and implement ways to keep chile pepper production profitable in New Mexico and to maintain and enhance the research and development partnership between the New Mexico chile industry and New Mexico State University.

Chile Task Force reports will be issued periodically to consider issues of concern to the industry and to document the Task Force's progress in developing techniques and technologies to improve industry competitiveness in the 21<sup>st</sup> century global trade environment.



**New Mexico Chile Task Force  
Advisory Board:**

**Dino Cervantes, Chair 2005**  
General Manager  
Cervantes Enterprises Inc.

**Louis Biad**  
President  
Rezolex, Ltd. Co.

**Ed Curry**  
President  
Curry Seed and Chile Co.

**Robert Flynn**  
Soil Scientist  
NMSU's Extension Plant Sciences

**Lupe Garcia**  
Owner  
Garcia Farms

**Ed Hughs**  
Research Leader  
USDA, ARS Southwestern Cotton  
Ginning Laboratory

**James Johnson**  
General Manager  
W. R. Johnson and Son

**David Layton**  
Agriculture Manager  
Border Foods Inc., HQ

**James Libbin**  
Professor  
NMSU Agricultural Economics and  
Agricultural Business

**David Lucero**  
Marketing Specialist  
New Mexico Department of Agriculture

**Lewis Needhams**  
Manager  
Southwest Spice

**Richard Phillips**  
Senior Project Manager  
New Mexico Chile Task Force  
NMSU College of Agriculture and Home Economics

**Rhonda Skaggs**  
Professor  
NMSU Agricultural Economics and Agricultural Business

**Stephanie Walker**  
NMSU Extension Vegetable Specialist  
NMSU Agronomy and Horticulture

---

**For more information, contact:**

New Mexico Chile Task Force  
Rich Phillips, Senior Project Manager  
New Mexico State University  
College of Agriculture and Home Economics  
Gerald Thomas Hall (Room 295)  
MSC 3AE  
P.O. Box 30003  
Las Cruces, NM 88003-8003  
Phone: (505) 646-2353  
Fax: (505) 646-3970  
E-mail: [rphillip@nmsu.edu](mailto:rphillip@nmsu.edu)



# Good Agricultural Practices: What Growers Should Know<sup>1,2</sup>

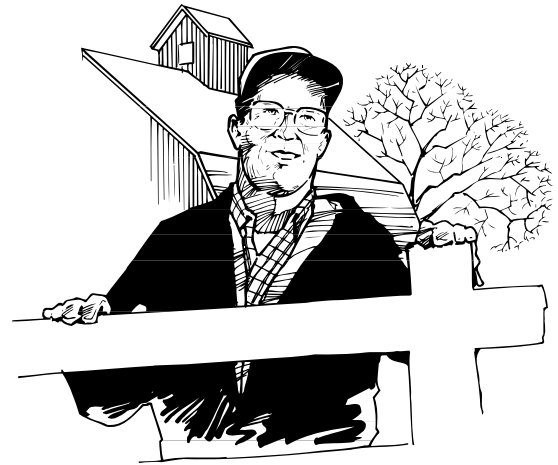
Roy D. Pennock and Nancy C. Flores<sup>3</sup>

---

## Making Good “Calls” in the Farm Field

Years ago a rookie baseball umpire was calling his first major-league game. Hall-of-famer Nolan Ryan was on the mound. Ryan’s second pitch was so fast that the umpire didn’t see it. He froze and, after a couple of seconds, collected himself and yelled, “Strike.” The batter stepped out of the box and said, “Don’t feel bad, Ump. I didn’t see it either.”

Today’s agricultural producers may feel like that rookie umpire. Every day on the farm they have to make judgment calls in response to changes and challenges that they may not have seen or anticipated. In the area of food safety, changes in acceptable on-farm practices are occurring very rapidly. Many new standards have been proposed to alleviate health and safety risks before serious or widespread problems occur. The Good Agricultural Practices (GAPs), summarized at the end of this report, address daily on-farm activities and alert growers to procedures that promote safe handling of produce. While the occurrence of foodborne illnesses resulting from on-farm handling of produce are still relatively rare, a single outbreak where death occurs is a tragedy for the victim and his family. A single outbreak also can devastate a business and adversely affect an entire produce sector. The information presented in this report will help growers understand the changing environment and health risks inherent in on-farm handling of produce and in other on-farm activities. Careful attention to GAPs will help growers make good calls to ensure the safety of employees and consumers.



## Keys to Produce Food-Safety

Many agricultural producers grew up on small family farms where they raised hogs and milk cows, drank unpasteurized milk and ate products made from that milk. Their families sold meat without USDA inspection and ate and sold produce from a truck patch that was

---

<sup>1</sup> The authors wish to thank the New Mexico Departments of Agriculture and Health for funding this project.

<sup>2</sup> This article was reviewed by Jeff Witte, Director, Agriculture Biosecurity, New Mexico Department of Agriculture, Las Cruces; and Stephanie Walker, Extension vegetable specialist, Extension Plant Sciences Department, and Erin Silva, assistant professor, Agronomy and Horticulture Department, New Mexico State University, Las Cruces.

<sup>3</sup> GAPs research specialist (rpennock@nmsu.edu) and food technology specialist (naflores@nmsu.edu), respectively, New Mexico Cooperative Extension Service, New Mexico State University, Las Cruces.

fertilized with manure. Handwashing was something that occurred when the family gathered for dinner. As far as anyone knows, the family and the neighbors never got sick from eating these home-grown products. Yet, by today's standards, almost everything that could be done wrong was done wrong. Changes in dietary habits and changes in disease-causing organisms have prompted new, stricter food-handling practices. New standards are based on several key principles:

❑ **Prevention.** Human pathogens do not normally occur on fresh produce. They have to be placed there by someone or some operation, so prevention of contamination is the key to providing safe produce.

❑ **Handwashing.** This is probably the single most important prevention measure that harvest crews and workers in packing facilities need to implement. As a society, we have failed in recent decades to teach even children to wash their hands properly. We see signs in rest rooms that say, "Employees must wash their hands before leaving the restroom and you should too!" Yet, according to a recent study reported in the *Journal of Food Protection*:

- Only 52 percent of the persons in charge could describe the handwashing procedure outlined in the food code.
- Only 48 percent of the food handlers could demonstrate handwashing according to the food code.

So, there is a pretty good chance that about half the people handling the produce in packing facilities need to wash their hands. That's a pretty scary thought about our farm-to-fork food chain.

❑ **GAPs audit and certification programs.** GAPs audit and certification programs have become a big business in the industry. Certification must be renewed yearly for each crop. While audits promote food safety and focus attention on its importance, they can be a financial burden on smaller, family operations.

All food safety programs are important, but in the end it is business that brings about change. The Food Safety Guide came out in 1998, but most businesses didn't respond right away. It was only when the food industry started to demand that companies comply with recognized good agricultural practices that we began to see changes in the industry. In the chile industry, some producers provide almost no food safety training while others are doing a very good job.

❑ **Borders.** *National Geographic* recognizes 191 independent nations in the world. USDA Web sites show that we import food from about two-thirds of these countries. It is very important that produce safety information we develop or use in our own programs be extended throughout the world. The GAPs program is currently evolving worldwide. It's important that domestically we be on the forefront of this evolution in food safety.

❑ **Consumer responsibility.** How many times have you known someone who got sick and said, "You know, that food I ate yesterday didn't taste exactly right, but I went ahead and ate it anyway." So, even when you're lifting the fork to your mouth, you still have to take responsibility for yourself when you sense something is wrong.

## Produce Food-Safety Risk Assessment

In the mid-1990s, a foodborne illness outbreak attributed to *Escherichia coli* O157:H7 was linked to farm-level contamination of California lettuce. Another large outbreak was linked to Guatemalan raspberries contaminated at the farm-level with the parasite *Cyclospora*. Additionally, imported Mexican strawberries were associated with *Hepatitis A* contamination and Mexican cantaloupe with *Salmonella*. While these highly publicized produce-related outbreaks raised consumer awareness of food safety problems, in reality, the proportion of foodborne illness outbreaks associated with handling of fresh produce is very low. The proportion attributed to **on-farm handling** is even lower. According to a report commissioned by the Alliance for Food and Farming (1) in 2004:

- Only 12 percent of U.S. foodborne illness outbreaks between 1990 and 2001 were traced to fresh fruits and vegetables.
- “Grower” associated outbreaks comprise only 2 percent of all traceable foodborne illness outbreaks in the U.S.

In New Mexico, the crop safety record is even better, with no documented foodborne illness outbreaks associated with fresh produce (2).

While the risk of contamination at the crop level is low, statistics show that it is increasing as dietary habits change, more food is imported, and as production is increasingly centralized and distributed over broader geographic areas to more people (3, 4). There is evidence that pathogens themselves are evolving and may cause illness at lower levels and survive in hostile environments. There is also an increase in the population of susceptible individuals, including the elderly and immuno-compromised (4).

To ensure a safe food supply, it is imperative that those who handle raw produce at every stage, from the field to the point of consumption, understand and implement safe handling practices to prevent contamination and outbreak of disease (3). While the primary focus of this risk assessment is on-farm handling of produce, it also identifies other, more common, areas of potential contamination. It identifies the primary pathogens of concern and the GAPs that can be used as “crop risk assessment tools” to minimize on-farm produce contamination.

## Mechanism of Contamination

Produce can become contaminated with microbial pathogens by a wide variety of mechanisms (fig. 1) at many points in the food chain:

- during production or harvest,
- during processing,
- at the retail, food service level, or
- in the home kitchen.

Contamination at any point in the chain can be exacerbated by improper handling and storage of a product prior to consumption. For example, fruit flies may transfer *Escherichia coli* O157:H7 to damaged apples, having implications for packing sheds or processing facilities, where damaged produce is inevitable and flies may be difficult to control (5).

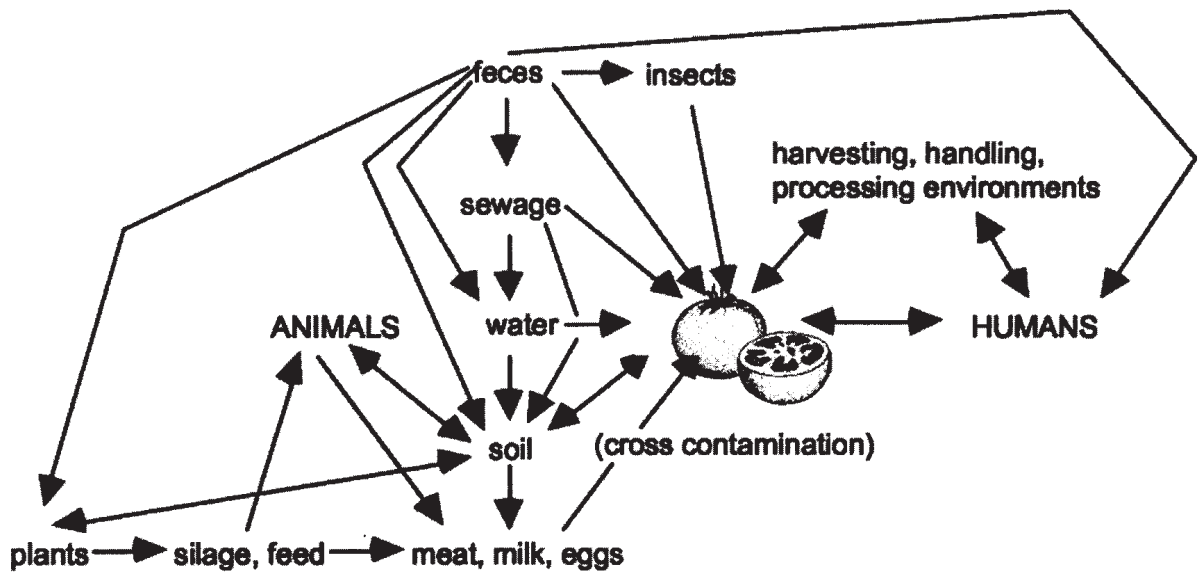


Figure 1. Mechanisms by which produce can become contaminated with pathogenic microorganisms (4).

### On Farm Contamination

As raw agricultural products, fresh produce should be expected to harbor a wide variety of microorganisms, including some pathogens. After all, with the exception of greenhouse operations, produce is still grown outdoors, and animals, birds, and insects can all carry human pathogens. Spores of *Clostridium* species, including *C. botulinum* and *C. perfringens*, and their access to fields can be controlled only to a limited extent. The spores of enterotoxigenic *Bacillus cereus* are commonly found in soil, so their occasional presence on fruits and vegetables should be expected (6). In addition, irrigation water, water used to apply fungicides and insecticides, inadequately composted manure, human handling, harvesting equipment, transport containers and vehicles, rinse water, ice, and transport vehicles may all be sources of bacterial contamination of fresh produce at the farm (7).

### Naturally occurring contaminants

Many studies show that probably the most prevalent disease-causing microorganism in soil is *Listeria monocytogenes*. In a Netherlands study, 27 strains were isolated from soil and vegetation taken from 19 sites, and in Germany, 154 strains of *L. monocytogenes* were isolated from soil and plants. In a vegetation analysis in Virginia, eight of twelve sampling sites yielded plant materials positive for *L. monocytogenes*. It should be noted that while *Listeria* is common in soil, some strains (perhaps as many as 75 percent) are incapable of causing human illness (6).

Wild birds are probably the second most prevalent source of natural contamination, disseminating *Campylobacter*, *Salmonella*, *Vibrio cholerae*, *Listeria* species and *E. coli* O157:H7 (6). Pathogenic bacteria apparently are picked up as a result of birds feeding on garbage, sewage, fish, or lands that are grazed with cattle or have had applications of fresh manure.

## Pathogens from agricultural treatments

The presence of other pathogenic bacteria, viruses and parasites in soil results largely from application of green manure or untreated sewage, either by chance or design (6). In these cases, soil on the surface of fruits and vegetables may harbor pathogenic microorganisms that can remain viable through subsequent handling. Irrigation and surface run-off waters can be sources of pathogenic microorganisms that contaminate fruits and vegetables in the field. Irrigation water containing raw sewage or improperly treated effluents from sewage treatment plants may contain *hepatitis A*, Norwalk viruses, or enteroviruses (poliomyelitis, echoviruses, and Coxsackie viruses). *Listeria* and other potentially pathogenic bacteria have been reported in sewage. The use of sewage as a fertilizer could contaminate vegetation destined for human consumption.

Grazing on or near cultivated areas also can be a source of pathogens, such as *Salmonella*, *E. coli* O157:H7, and *Listeria monocytogenes*, as can other types of contamination by manure. In the production of seeds intended for sprout production, the practice of animal grazing to initiate flowering of alfalfa may result in the introduction of enteric bacteria. Similar consequences may result from allowing wild animals access to seed fields. Non-composted or improperly composted manure can contaminate fruits and vegetables through uses such as a fertilizer or soil amendment, or in irrigation water (7). A recent *Cryptosporidium* infection was linked to consumption of unpasteurized apple juice that is hypothesized to have been caused by contamination of apples by calf feces (6).

## Postharvest Contamination

Contamination may also occur during postharvest handling, including workers handling fruits and vegetables from the point of removal from the plant; at farmers' markets; at points of preparation by street vendors; in retail food-service establishments and in the home (3).

## Control Measures

While pathogens cannot be totally eliminated from produce, there are a number of things that can be done to significantly reduce the risk of contamination. **All potential “mechanisms of contamination” should be evaluated systematically on each farm, using GAPs as an assessment tool**, and in each processing or food service facility, using Hazard Analysis Critical Control Points (HACCP). Where possible, control measures should be implemented (6).

For example, to limit the introduction of pathogenic bacteria through irrigation, the origin and distribution of irrigation water, as well as the history of the land, should be known. Irrigation wells should be well-maintained, and all irrigation sources should be monitored for human pathogens. Manure used as fertilizer should be treated to eliminate pathogenic microorganisms (e.g., composting or aging, and animals (domestic or otherwise) should be excluded from produce and sprout seed production fields. A maximum amount of time (at least 120 days) should be scheduled between the final manure application and harvest.

During post-harvest, high levels of worker hygiene should be enforced; human waste management at production sites should follow local laws (7). Proper training of field and packing-shed workers in hygienic practices is essential. One cannot assume that newly hired personnel have even rudimentary knowledge of food microbiology (6).

Elimination of animals and insects from processing, storage, marketing and food-service facilities should be a goal of anyone who handles raw produce. The highest level of hygiene must be practiced by all handlers (including consumers) of fruits and vegetables, from the field to the table. GAPs is designed for implementation at the farm. However, it will not prevent illness due to post-harvest cross-contamination at any point, including foodservice environments or in the home (5).

## Good Agricultural Practices for New Mexico

### Background Research

Exhaustive Internet research, literature reviews and consultation with a New Mexico Department of Health epidemiologist identified no foodborne illness outbreaks in New Mexico that could be directly linked to “on-farm” handling of produce. To determine whether New Mexico’s record is typical, research was expanded to the entire U.S. Searches on the Internet and of “Centers for Disease Control” records showed that relatively few pathogens have been isolated on fresh produce (table 1) and that very few foodborne illness outbreaks associated with these pathogens could be traced to the farm or farming practices (table 2).

It may be concluded that up to this point, the risk of foodborne illness outbreaks resulting from agronomic practices is negligible. Nevertheless, one can identify sources and pathways that can exist in a farming operation that possibly could contaminate fresh fruit and vegetables crop. **These “pathogen sources and pathways” are at the very core of what makes GAPs the best possible “crop risk assessment tool” available to address microbial pathogen contamination on the farm. The “pathogen sources and pathways” presented here are addressed in the GAPs self-assessment and good agricultural practices.**

#### **Preharvest “Pathogen Sources and Pathways”**

- Feces
- Soil
- Irrigation water
- Water used to apply pesticides, foliar treatments, growth hormones
- Green or inadequately composted manure
- Air (dust)
- Wild and domestic animals (including fowl and reptiles)
- Insects
- Human handling

#### **Postharvest “Pathogen Sources and Pathways”**

- Feces
- Human handling (workers, consumers)
- Harvesting equipment
- Transport containers (field to packing shed)
- Wild and domestic animals (including fowl and reptiles)
- Insects
- Air (dust)

**Table 1 – Microbial pathogens that have been associated with fresh produce. (Substantiated by Ref. 3 ,4, 5, 7, & 8)**

Microorganism	Incubation Period	Symptoms	Infectious dose (# of cells)	Source	Produce from which pathogens have been isolated
<b>Bacteria</b> <i>E. coli</i> 0157:H7	2 to 5 days	Watery diarrhea often containing blood, abdominal pain. Can lead to hemolytic uremic syndrome and kidney failure, especially in children	10 to 1,000	Animal feces, especially cattle, deer and human	Apple cider, alfalfa sprouts, lettuce, radish sprouts
<i>Salmonella</i> spp.	18 to 36 hours	Abdominal pain, diarrhea, chills, fever, nausea, vomiting	10 to 100,000	Animal and human feces	Alfalfa sprouts, apple cider, melons, tomatoes, lettuce, parsley
<i>Shigella</i> spp.	1 to 3 days	Abdominal pain, diarrhea, fever, vomiting	10	Human feces	Lettuce
<i>Aeromonas</i>	Unknown	Cellulitis and diarrhea	Unknown	Bacteria present in water, isolated on vegetables	Alfalfa sprouts, asparagus, broccoli, cauliflower, celery, lettuce, parsley, pepper, spinach
<i>Bacillus cereus</i>	1 to 6 hours	Nausea, vomiting, watery diarrhea, abdominal pain, rapid recovery	>10,000	Raw foods of plant origin, soil, dust, air, water	Alfalfa sprouts, cress sprouts, cucumbers, mustard, sprouts, soybean sprouts
<i>Campylobacter jejuni</i>	2 to 5 days	Muscle pain, headache, fever, followed by diarrhea, abdominal pain, nausea	1,000 to 10,000	Guts of ruminant animals and birds are primary reservoir.	Green onions, lettuce, mushroom, potato, parsley, pepper, spinach
<i>Clostridium botulinum</i>	12 to 36 hours	Mild disease to illness that can be fatal within 24 hours; nausea and vomiting followed by neurological symptoms	From 0.1 to 0.3ug can kill humans.	Type A strongly associated with vegetable products.	Asparagus, cabbage, mushrooms, pepper, potatoes
<i>Listeria monocytogenes</i>	Invasive: 1-90 days; Non-invasive: 11 hours to 7 days	Invasive: fever, headache, diarrhea, vomiting, meningitis, septicaemia, spontaneous abortion Non-invasive: diarrhea, fever, muscle pain, headache, abdominal cramps, vomiting	Invasive: 100 to 1000 Non-invasive: > 50,000	Foodborne transmission is primary source of human infections.	Bean sprouts, cabbage, chicory, cucumber, eggplant, lettuce, mushrooms, potatoes, radish, salad vegetables, tomatoes
<i>Staphylococcus</i>	30 minutes to 7 hours	Nausea, vomiting, diarrhea, abdominal cramps, headaches, sweating, fever	>10,000	Humans are main reservoir.	Alfalfa sprouts, carrots, lettuce, onions, parsley, radish
<i>Vibrio cholerae</i>	12 to 72 hours	Cholera: mild diarrhea to copious pale grey stools, low blood pressure, nausea, cramps, occasional fever, de-hydration	1,000,000	Humans are main reservoir. Also, aquatic microscopic animals in contaminated water.	Cabbage, coconut milk, lettuce
<b>Parasites</b> <i>Cryptosporidium</i> spp.	1 to 12 days	Profuse watery diarrhea, abdominal pain, anorexia, vomiting	<30	Human and animal feces	Apple cider
<i>Cyclospora</i> spp.	1 to 11 days	Watery diarrhea, nausea, anorexia, abdominal cramps (duration 7 to 40 days)	Unknown, probably low	Human and animal feces	Raspberries, basil, lettuce
<b>Viruses</b> <i>Hepatitis A</i>	25 to 30 days	Fever, malaise, anorexia, nausea, abdominal pain, jaundice, dark urine	10 to 50	Human feces and urine	Frozen strawberries, lettuce

**Table 2. On-farm microbial pathogens outbreaks that have been associated with fresh produce.**

Microorganism	Ref	Date	Documented Outbreaks	Mode of Contamination	
<b>Bacteria</b> <i>E. coli</i> 0157:H7	9	Sep-99	Attendees of Washington County Fair	Well water	
	10	Jun/July-97	Outbreak associated with eating alfalfa sprouts	Seed lot	
	11	Oct-96	Outbreak from drinking unpasteurized apple cider	“Drop apples” from manure	
	<i>Salmonella</i> spp.	12	Abstract	Persistence of Salmonella on lettuce and parsley	Manure compost/water
		13	2000/2002	Outbreaks associated with eating cantaloupe	Water/worker hygiene/sanitary facilities
	<i>Shigella</i> spp.	14	Aug-98	Oubreak from eating fresh cut parsley	Water/worker hygiene/sanitary facilities
	<i>Aeromonas</i>	15	Abstract	Enumeration and characterization of Aeromonas	Grocery store produce
	<i>Bacillus cereus</i>			Could find no listed documented outbreaks	
	<i>Campylobacter jejuni</i>			Could find no listed documented outbreaks	
	<i>Clostridium botulinum</i>			Could find no listed documented outbreaks	
	<i>Listeria monocytogenes</i>			Could find no listed documented outbreaks	
	<i>Staphylococcus</i>			Could find no listed documented outbreaks	
	<i>Vibrio cholerae</i>			Could find no listed documented outbreaks	
	<b>Parasites</b> <i>Cryptosporidium</i> spp.			Could find no listed documented outbreaks	
		<i>Cyclospora</i> spp.	16	May-98	Outbreak associated with eating fresh raspberries
17			Jul-97	Outbreak associated with eating fresh basil	Not determined*
18			May-96	Outbreak associated with eating fresh raspberries	Not determined*
19			Apr-97	Outbreak associated with eating fresh raspberries	Not determined*
20			Apr-97	Outbreak associated with eating fresh raspberries	Not determined*
21			Jun-97	FDA Paper – Cyclosporiasis and Gautemalan Raspberries	
<b>Viruses</b> <i>Hepatitis A</i>	22	1987	Louisville, Ky. Suspected source: imported lettuce	Not determined*	
	22	1990	North Ga. Frozen strawberries from Montana	Not determined*	
	23	1997	Hepatitis A associated with frozen strawberries	Not determined*	
	24	1997	Hepatitis A and strawberries	Not determined*	

- Wash and rinse water
- Sorting, packing, cutting, and further processing equipment
- Ice
- Transport vehicles
- Improper storage (temperature, physical environment)
- Improper packaging (including new packaging technologies)
- Cross-contamination (from other foods in storage, preparation, and display areas)
- Improper display temperature
- Improper handling after wholesale or retail purchase
- Cooling water (for example, hydro cooling)

## **GAPs – Good Agricultural Practices**

The Good Agricultural Practices or GAPs program was designed by Cornell University with support from the USDA Cooperative State Research, Education and Extension Service (CSREES) and the U.S. Food and Drug Administration (FDA) to address consumer concerns about foodborne illness in fresh produce. The GAPs Manual (25) will help a grower to do a crop-risk assessment of his operation, identifying his strong and weak areas (control points). The program will help him to create an action plan that pinpoints what needs to be done to minimize the risk of crop contamination, identifies the party responsible, the cost, and the target dates for completion of each segment of the action plan. The following recommendations for minimizing crop risk are from the GAPs program.

Growers can minimize the preharvest risk of contamination from pathogen sources such as irrigation water, green or inadequately composted manure, or wild animals, through the following GAPs practices:

### **Irrigation and Spray Water Quality**

- Irrigation water is from a capped well in good condition that can be readily treated if indicator organisms are detected in annual water test.
- Source of water for topical sprays is from a capped well in good condition that can be readily treated if indicator organisms are detected in annual water test.
- All water sources are tested for indicator organisms such as thermotolerant coliforms and generic E. coli with records kept on file.
- Findings and efforts of local watershed committees are known.
- Records are kept of monitoring of sediment levels in surface water used for irrigation.
- Irrigation method used for fresh produce is known to be free from pathogens.
- Backflow prevention is in place with no cross connections between water supplies.
- Self-assessments or consultant assessments are made (and documented) to reduce negative environmental impacts of farming practices.

### **On-Farm Wells**

- Well casing and well cap seal condition are good.
- Recommended well-casing depth is verified with local health department.
- Records are maintained of location and maintenance of on-farm septic systems.
- Records are kept of well positions and distances in relation to potential contamination sources (e.g. fertilizer or pesticide storage and handling areas, livestock yards, septic leach fields, manure piles, fuel storages, direction of surface water runoff, and diversions of surface water runoff).

- Record/diagram exists of anti-backflow or check-valve devices on plumbing (indicate if cross connections exist between water supplies).
- Records of all annual water tests are on file (tested for nutrients and chemical/microbial contaminants).

### **Manure Sources and Application Practices**

- Manure handling documentation from provider is on file.
- Only mature-animal manure is applied to produce fields (never from young, immature animals).
- Time between manure application and harvest is always maximized.
- Pathogen contamination risks on recently manured ground are considered when making crop choices. (For example, never plant lettuce or root crops on recently manured ground).
- Manure teas are never used.
- No manure is used to side dress produce crops.
- Barriers are used to reduce manure runoff or movement to surface water sources, to minimize risks of pathogen contamination of water used by downstream neighbors.
- Produce is not grown in fields that might receive manure run-off.
- Manure is never spread to fields that are water saturated, prone to flooding or runoff, and is not spread on frozen or snow-covered ground.
- Detailed records are kept of manure use.

### **On-Farm Manure Storage and Handling**

- Manure storage areas are isolated from produce fields and handling facilities.
- Proper slurry storage periods are observed, prior to field application.
- Manure storage facility is covered, and there is no opportunity for liquid runoff.
- Surface diversions are present to prevent clean water from entering manure storage.
- There are records of slurry storage engineering design and inspection, with emergency plan for pit failure or spills.
- There are records on file of farm environmental impact assessment, with record of necessary changes made.

### **Compost Sources and On-Farm Storage**

- Compost handling documentation from the provider is on file.
- Records of composting conditions for manure and bedding are on file.
- On-farm compost storage is secured, prior to land application.

### **Compost Application Practices**

- No compost teas are used.
- No produce crops are side dressed with compost.
- Barriers are in place to reduce compost runoff or movement to surface water sources.
- There is detailed record keeping of compost use.

### **Herd Health**

- Standard operating procedures (SOPs) or protocols are written to protect herd health and are updated continuously based on consultant or vet advice, all of which are recorded.
- Manure handling of young or new animals is separate from older animals, clean water movement on-farm is protected through containment of barnyard runoff, restriction of

animals from water courses, and restriction of domestic animals from production fields and irrigation ponds.

### **Wild Animals**

- Wild animals are restricted from production fields and irrigation ponds.
- SOPs are written for pest control of rodents, birds and insects for storage and packing areas, with recorded weekly inspections.
- Cull pile is managed at proper location with daily composting or appropriate removal.

### **Worker Hygiene**

- Workers receive training on handwashing and personal hygiene for food safety.
- Management exists of worker training programs on food safety and personal hygiene.
- On-farm signage of personal hygiene requirements is posted – instructions for handwashing and personal hygiene for food safety in English and non-English (diagrams for benefit of illiterate workers).
- Worker illness is reported, as required.
- Records are kept of worker training.

### **Toilets and Handwashing**

- Clean toilet facilities are provided for farm laborers, visitors and customers.
- Toilets and hand-washing facilities are well maintained and stocked with supplies.
- Field toilets are located so as to be readily available to workers, but physically isolated from all produce production or handling areas.
- Gray water is collected from handwashing facilities in the field.
- Emergency containment and treatment plans for portable toilets are in place.
- There are servicing areas for portable toilets.
- Ratio of toilets to workers is sufficient to accommodate all workers.
- SOPs are written for all aspects of toilet and handwashing facilities maintenance, sanitation and emergency spill containment.
- Records are kept documenting implementation of these SOPs.

Harvest and Postharvest sources of contamination are addressed under GAPs as follows:

### **Harvest Sanitation**

- Workers are trained regarding quality and grade of harvested product.
- Harvest aids, field packing equipment and machinery are washed and sanitized daily.
- Workers practice proper handwashing.
- Gloves are used properly while harvesting.
- Proper procedures are followed when loading field bins. (Workers are not allowed in bins.)
- Harvesting, packing and shipping containers are new or clean and sanitized prior to each use.
- Containers used for packing produce are properly stored.
- Soil is removed from produce and bins in field. Bins are cleaned and sanitized prior to field use.
- Written SOPs exist for all aspects of field harvest sanitation, with documentation that SOPs are being implemented.

### **Postharvest Packing House Sanitation and Safety**

- Written SOPs for pest control of rodents, birds and insects in storage and packing areas, with daily inspections and records.
- Soil is removed from produce and bins in field.
- Overhead light bulbs are screened or covered.
- Backflow devices are in place to protect water source.
- Written SOPs exist for packing line sanitation and damage inspection, with daily inspection records.
- Good grade oils and lubricants are used.
- Proper storage of containers used for packing and shipping ensure containers are not exposed to rodents, dust or condensation.
- Cull pile management occurs at proper location, with daily composting or appropriate removal.
- Workers practice proper handwashing.
- Gloves, smocks and aprons are properly worn during packing.
- Shipping trucks are properly sanitized, with recorded documentation.
- There are written SOPs for all aspects of packing house sanitation, with records of routine verification of practices.

### **Postharvest Handling of Produce**

- Soil is removed from produce and bins in field to prevent contaminating wash water or other loads of produce.
- Potable-quality water is used for washing produce and making ice, with results of annual water test on file.
- Water quality in dump tanks, flumes, hydro coolers or other batch-water tanks is monitored several times a day, with appropriate chlorine or other disinfectant levels maintained for each particular crop. Water pH is monitored and adjusted to correct levels.
- There are written SOPs for temperature management of water in dump tanks (no more than 10° F cooler than produce).
- Records are maintained of scheduled cleaning of ice storage and handling facilities.
- Backflow devices separate dump tanks from water source.
- Harvesting, packing and shipping containers are new or clean and sanitized prior to each use.
- Proper storage of containers used for packing and shipping ensures containers are not exposed to rodents, dust or condensation.
- A cold chain is maintained to minimize growth of pathogens, with records of monitored temperatures.
- There are written SOPs for cleaning of temperature-controlled produce storage, with records to verify implementation.
- There is proper refrigerated- or cold-room loading and management.
- Refrigerated or temperature-controlled trucks are used to move produce optimizing crop postharvest quality. Temperatures are printed on manifests to ensure maintenance of the cold chain. Temperature monitoring records are kept.
- Prior to loading produce, shipping vehicle is inspected for cleanliness, odors and debris, and cleaned and sanitized, if needed. Records are kept.
- A trace-back system is implemented on the farm, coding for field, harvest date and crew, with records maintained for access by grower, auditor or inspector.

- SOPs are in place for produce washing, cooling, storage and shipping, with records that include routine verification of practices.

The GAPs program also provides guidelines for the following agricultural management areas that are a key part of reducing the “on-farm” microbial risk:

### **Record Keeping**

- Farm records demonstrate adherence to SOPs and scheduled protocols, such as monitoring of restrooms, worker training, product coding, and postharvest sanitation. When variations in protocols occur, they are noted in the records. All farm records are verified by management and kept on file.
- Product identification is in place for each piece or container of produce shipped from the farm. It is coded to allow tracing from field or origin to the distributor. The coded lot numbers are included on the bill of lading.
- Records of results of annual self-assessments, including action plans and dates of implementation, are kept on file.
- A written recall plan is updated and reviewed regularly by farm management and employees. Copies of the plan are filed with farm support services, including lawyers and distributors.
- The written recall plan includes names of employees to serve as recall team leaders, process for notification of the public and regulatory agencies, procedures for implementing the recall, strategies for handling recalled produce and methods for verifying recall plan effectiveness.
- Recall Notification Contacts include current phone and fax numbers for the key farm personnel, produce buyers and distributors, and farm support agencies. Notification will include request that all contacted parties reply to the notice.
- A mock recall is conducted on the farm to test the recall strategy and verify trace-back procedures.
- Records of any customer complaints, responses and actions taken to fix problem are kept on file.

### **Farm Biosecurity**

- Farm and packing shed buildings are locked when not occupied. Access keys are restricted to designated farm personnel.
- Visitor protocols limit and monitor access of all non-employees. These protocols are documented and all employees are aware of them.
- Standards for employee hiring are developed with consideration for biosecurity.
- All employees are trained to notify their supervisor if they see suspicious vehicles or people, unusual product or suspicious packages on the farm, in the packing shed or around farm buildings.
- Public Health, Security and Bioterrorism Preparedness and Response Act of 2002—Farm owner, operator or manager is aware of the act and understands how their operation is affected.
- Farm operation qualifies as a food production facility under this act and has been registered.

### **Crisis Management**

- Farm owner/operator has received crisis management training, and a written crisis management plan is in place.
- The farm has individuals who have media training and are familiar with farming operations to answer questions from the media. These individuals are familiar with all farm food safety protocols that are in place to prevent problems.
- The farm has a crisis management team designated and a plan to assign employees to different tasks should a crisis occur. Each critical person has a backup.
- Employee training includes discussion of the crisis management plan and employee responsibilities in the event of a crisis.
- The crisis management plan outlines which operations must continue and those that can be temporarily halted during a crisis.
- The crisis management plan includes a list of all priority contacts that support or provide services to the farm in the event of a crisis including lawyers, grower organizations, state health officials and vendors.
- A mock crisis has been conducted to insure the plan is effective.

### **Pesticide Use**

- Pesticides are applied according to label directions and at less than label rates when effective.
- A spill kit is readily available near mixing area. A holding tank for rinsate is available. Excess material and rinsate is used according to label instructions.
- A spill response plan is written, updated and routinely reviewed by farm management and employees. Phone numbers of emergency response personnel are posted near all phones and authorities are notified immediately after a spill of a hazardous compound.
- SOPs are written for maintenance, calibration and inspection of spray equipment.
- Records of spray equipment maintenance are kept.
- A drift management plan is written and followed.
- Records of all pesticide applications are kept on file (includes date, chemical and trade name, EPA registration number, rate applied, weather conditions, stage of crop, target pest, area treated and name and certification number of applicator).
- Crops are inspected for pests during critical periods of crop and pest development. The farm uses IPM and pesticides. Pesticides are only applied when pest populations are large enough to cause economic losses.
- Spray water is from a municipal, treated water source or from ground water obtained from a properly constructed, capped well, in good condition, that could be readily treated if indicator organisms were detected in annual water tests.
- Any person who handles and applies pesticides is a certified applicator.
- All pesticide applicators have access to and wear proper safety equipment for applying pesticide.
- The pesticide storage area is locked and used only for pesticides.
- Pesticide storage area is designed with impermeable shelves over and impermeable floor with curbs or dikes to contain leaks or spills. There is no floor drain or drain is to an acceptable holding tank.
- Signs are posted notifying of pesticide applications. Workers are prevented from re-entry to fields until the re-entry period has expired.

- No produce is harvested until the legal number of days, post application, as stated on the pesticide label.
- Proper pesticide container disposal is followed.

### **Juice and Cider**

- Farm personnel who control cider production are trained and certified in Juice HACCP. Cider is produced only when certified person is present. Records are kept.
- All juice and cider produced for wholesale is pasteurized. Records are kept.
- Dropped apples never are used in the production of non-pasteurized cider. Apples used for non-pasteurized cider are sanitized prior to juicing.
- Non-pasteurized apple juice and cider for growers who direct market must be labeled so consumers recognize risk. Grower must direct-market only to consumer.
- Patulin content in apple juice and cider is tested at least once pre-season. Producers who press apples after December and throughout the next year need to test at least three times.
- Citrus juice is pasteurized prior to sale or citrus fruit is treated to achieve 5-log reduction prior to squeezing. A 5-log reduction is an industry standard to reduce high bacterial contamination levels to low contamination levels suitable for public consumption. Reduction method must be scientifically valid.
- Farm owner and manager are aware of Juice HACCP regulation and use them in their operation.

### **Direct Marketing**

- All workers practice proper handwashing before work, before and after meals/snacking, and after toilet use.
- Toilet and handwashing facilities are readily available for all employees and customers.
- Regular daily maintenance and cleaning of toilets and handwashing facilities is done. A cleaning record is kept by the market manager indicating time, date and person who performed maintenance and cleaning.
- Pets, including farm animals, are never permitted in packing areas or farm markets.
- Covered garbage containers are readily available for customer use.
- Produce used for samples is always washed in potable, cool water prior to preparation.
- Everyone preparing or serving samples is trained in proper handwashing and use of clean, sanitized utensils. Clean, disposable gloves are worn to stop bare-hand contact with cut, ready-to-eat produce.
- All utensils used for cutting samples, including cutting surface and knives, are washed, rinsed and sanitized prior to use.
- Cut samples are stored in food-grade containers and kept on ice or in a cool ice chest at or below 41oF until they are served.
- Samples are served in a covered container on ice. If samples are not held cold, they are disposed of after four hours. End of the day leftovers are discarded.
- Toothpicks and plastic utensils are provided for customers who taste the samples.
- Low acid canned foods such as vegetables, meat and fish are not sold unless they are processed at an approved, low-acid facility following a scheduled process by a certified operator.

### **U-Pick Operations**

- Toilets and handwashing facilities are readily available for customer use.
- Regular daily maintenance and cleaning of toilets and handwashing facilities is done. A cleaning record is kept indicating time, date and person who performed maintenance and cleaning.
- Signs clearly mark toilet locations. Signs request that customers wash their hands after using the toilet, prior to field entry and before eating. Sign displays are written in the language(s) of the customers.
- Mulch used between rows is clean straw, which has not been used previously as animal bedding.
- Wild animals are restricted from production fields and irrigation ponds (as much as possible).
- Domesticated animals on the farm never are permitted in produce fields, or adjacent fields that may have water or manure runoff into the produce fields.

### **Petting Zoos and Farm Animals**

- The petting zoo has a unidirectional exit with well-stocked handwashing facilities. In case of exhibits with multiple exits, all have well-stocked handwashing facilities. Access to animal water troughs is restricted and staff person is in place to monitor the exhibit.
- Signs are posted near the petting zoo, as well as in areas where food is served, to encourage handwashing after exiting petting zoo and prior to eating. A staff member is in place to monitor visitors and encourage proper handwashing.
- Clean eating areas are isolated from animal exhibits. Drinking water is provided. Signs are posted to encouraging visitors to wash hands prior to eating.
- There is culture/language-appropriate signage at petting zoos describing risks and need for adults to supervise children.
- There is signage about reporting to the exhibit manager any bites or scratches inflicted by animals as well as the first aid response to injuries (bites, scratches) caused by animals. SOPs are in place for dealing with injuries. A staff member is trained and available for first aid responses. Bites are reported to the health department.
- Up-to-date records of vaccinations are current for rabies and other communicable diseases. Animals too young for vaccinations are not on display.
- Petting zoo animal health is monitored daily, and sick animals are immediately removed from the area.
- Walls, fences or rails are rinsed and sanitized daily to remove any fecal matter or bedding. Manure is removed and fresh bedding is applied every day. SOPs are in place and records of maintenance are kept.
- Pets, including farm animals, are never permitted in produce fields or adjacent fields that may have water or manure run off into produce fields.
- Visitor access to U-pick production fields after visiting petting zoo is monitored. Appropriate hygiene is required prior to entering U-pick operations.
- Regular daily maintenance and cleaning of toilets and handwashing facilities is done. A cleaning record is kept indicating time, date and person who performed maintenance and cleaning.
- Signs clearly mark toilet locations. Signs request that customers wash their hands after using the toilet, prior to field entry and before eating. Sign displays are written in the language(s) of the customers.

## Conclusions and Concerns for GAPs as a “Crop Risk Assessment Tool”

A grower implementing a GAPs program will fully address all areas of concern, minimizing risk for foodborne illness outbreaks associated with on-farm produce handling. The GAPs Manual (25) provides growers with detailed steps for assessing crop risk in their individual operations. The program will help a grower create an action plan that pinpoints what needs to be done to minimize the risk of crop contamination, identify the party responsible for each task, calculate the cost, and target the dates for completion of each segment of the action plan.

However, there are several areas of concern. GAPs is a voluntary program. The USDA does not require growers to implement GAPs on their farms. Large retail operations, such as Albertsons, Safeway and Sysco, have begun to require that their fresh fruit and vegetable produce suppliers be “GAPs certified.” These retail produce buyers are requiring annual independent “third-party inspection” audits from their growers that show GAPs compliance. While this is certainly a positive step, there is still room for non-compliant produce to be marketed, as not all commercial companies require GAPs certification. And, in times of “short or low” produce availability, buyers’ certification conditions may be lifted.

In addition, there is no organized effort to self-regulate for food safety among small-acreage (farmers’ market) growers. While farm market managers and many small growers are concerned about food safety issues, they lack management, time and financial resources to implement food safety programs like GAPs. The cost of the certifications alone can be substantial. Certifications must be renewed yearly for each crop. GAPs implementation and passing a farm “audit” can require a steep learning curve. Few pass an audit the first time, meaning they will have to pay for it repeatedly. For the large commercial grower, with no compensation from the buyer for being GAPs compliant and certified, the burden of certification is another cost the grower must absorb, at a time that he is facing increasing costs across the entire farming operation. With the small, farmers’-market grower, the question is how much cost can be passed on and still maintain a viable farmers’ market.

Clearly, the approach should be that GAPs is not an all-or-nothing program. Large commercial operations facing self-regulation by the food industry, and small-acreage growers moving their fresh produce through local farmers’ markets, need to take the first steps in initiating a food safety program, understanding it may take two to three years to develop and fully implement. Cooperative Extension can help with workshops designed to aid growers in developing GAPs programs. It is imperative that farmers’ markets across New Mexico be encouraged to develop some kind of organized food safety program.

Even without utilizing a program like GAPs, history indicates that risk for a foodborne illness outbreak caused by pathogen contamination on the farm is very low in New Mexico. The flaw in this statement is that **only one** outbreak where death occurs can devastate a business and adversely affect an entire produce sector. A GAPs program will minimize the possibility of that one outbreak occurring. In today’s global political climate, it is also easy to envision the devastating effects of a foodborne illness outbreak from an “on-farm” act of agroterrorism. To minimize this possibility and the effects of such an occurrence, the GAPs program has management areas addressing biosecurity, traceback, recall and crisis management at the farm level. Also, it is important to note that with GAPs traceback, recall, and crisis management in place on New Mexico farms we would be better equipped to create an outbreak data base. This would give us a much better point of reference for determining what is occurring with foodborne illness outbreaks associated with on-farm produce handling in New Mexico.

## References

1. *Analysis of Produce Related Foodborne Illness Outbreaks*. (2004, April). Watsonville, CA: Alliance for Food and Farming. Retrieved from: [http://www.foodandfarming.info/documents/85876\\_produce\\_analysis\\_604.pdf](http://www.foodandfarming.info/documents/85876_produce_analysis_604.pdf)
2. Jungk, J., Epidemiologist, New Mexico Department of Health, Epidemiology and Response Division, personal communication via email.
3. Beuchat, L. R. (1998). *Surface decontamination of fruits and vegetables eaten raw: A review*. Food Safety Unit, World Health Organization. Retrieved from: [www.foodsafetynetwork.ca/food/who-surface-decontam.pdf](http://www.foodsafetynetwork.ca/food/who-surface-decontam.pdf)
4. Harris, L.J. (1997, August). Microbial pathogens associated with produce. *Perishables Handling Quarterly*, 91. Retrieved from: [ucce.ucdavis.edu/files/datastore/234-170.pdf](http://ucce.ucdavis.edu/files/datastore/234-170.pdf)
5. U.S.D.A. Center for Food Safety and Applied Nutrition. (2001, September 30). Outbreaks associated with fresh produce. Incidence, growth, and survival of pathogens in fresh and fresh-cut produce. In *Analysis and Evaluation of Preventive Control Measures for the Control and Reduction/Elimination of Microbial Hazards on Fresh and Fresh-Cut Produce*. Retrieved from: [www.cfsan.fda.gov/~comm/ift3-4a.html](http://www.cfsan.fda.gov/~comm/ift3-4a.html)
6. Larry R. Beuchat, L.R. & Ryu, J.-H. (1997, October-December). Produce handling and processing practices. *Emerging Infectious Diseases*, 3(4). Retrieved from: [www.cdc.gov/ncidod/eid/vol3no4/beuchat.htm](http://www.cdc.gov/ncidod/eid/vol3no4/beuchat.htm)
7. Buck, J.W., Walcott, R.R. & Beuchat, L.R. (2003, January 21). Recent trends in microbiological safety of fruits and vegetables. *APSnet/online* (online journal of the American Phytopathological Society). Retrieved from: [www.apsnet.org/online/feature/safety/Buck.pdf](http://www.apsnet.org/online/feature/safety/Buck.pdf)
8. FDA - Center for Food Safety and Applied Nutrition - *Bad Bug Book: Introduction to Foodborne Pathogenic Microorganisms ...* Information about foodborne pathogenic micro-organisms and natural toxins, including habitat or source, associated foods, infective dose, disease symptoms, ... Retrieved from: [vm.cfsan.fda.gov/~mow/intro.html](http://vm.cfsan.fda.gov/~mow/intro.html)
9. Centers for Disease Control. (1999, September 17). Public health dispatch: Outbreak of *Escherichia coli* O157:H7 and *Campylobacter* among attendees of the Washington County Fair -- New York, 1999. *Morbidity and Mortality Weekly Report*, 48(36): 803. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/mm4836a4.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/mm4836a4.htm)
10. Centers for Disease Control. (1997, August 15). Outbreaks of *Escherichia coli* O157:H7 infection associated with eating alfalfa sprouts -- Michigan and Virginia, June-July 1997. *Morbidity and Mortality Weekly Report*, 46(32): 741-744. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/00048994.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00048994.htm)
11. Centers for Disease Control. (1997, January 10). Outbreaks of *Escherichia coli* O157:H7 infection and cryptosporidiosis associated with drinking unpasteurized apple cider -- Connecticut and New York, October 1996. *Morbidity and Mortality Weekly Report*, 46(01): 4-8. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/00045558.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00045558.htm)
12. USDA – Agricultural Research Service (Environmental Microbial Safety) Persistence of *Salmonella Enterica* Serovar *Typhimurium* on lettuce and parsley and in soils on which they were grown in fields treated with contaminated manure composts or irrigation water. Authors: J., Doyle, M., Phatak, S., Millner, P. & Jiang, X. Retrieved from: [http://www.ars.usda.gov/research/publications/publications.htm?SEQ\\_NO\\_115=159722](http://www.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115=159722)

13. Centers for Disease Control. (2002, November 22). Multistate outbreaks of *Salmonella* serotype poona infections associated with eating cantaloupe from Mexico --- United States and Canada, 2000—2002. *Morbidity and Mortality Weekly Report*, 51(46): 1044-1047. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/mm5146a2.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5146a2.htm)
14. Centers for Disease Control. (1999, April 16). Outbreaks of *Shigella sonnei* infection associated with eating fresh parsley -- United States and Canada, July-August 1998. *Morbidity and Mortality Weekly Report*, 48(14), 285-9. Retrieved from [www.cdc.gov/mmwr/preview/mmwrhtml/00056895.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00056895.htm)
15. Callister, S.M. & Agger, W.A. (1987, February). Enumeration and characterization of *Aeromonas hydrophila* and *Aeromonas caviae* isolated from grocery store produce. *Applied Environmental Microbiology*, 53(2): 249–253. Retrieved from: <http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=203646>
16. Centers for Disease Control. (1998, October 2). Outbreak of *Cyclosporiasis* -- Ontario, Canada, May 1998. *Morbidity and Mortality Weekly Report*, 47(38): 806- 809. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/00055016.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00055016.htm)
17. Centers for Disease Control. (1997, August 1). Outbreak of *Cyclosporiasis* -- Northern Virginia-Washington, D.C.-Baltimore, Maryland, Metropolitan Area, 1997. *Morbidity and Mortality Weekly Report*, 46(30): 689-691. Retrieved from: ([www.cdc.gov/mmwr/preview/mmwrhtml/00048551.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00048551.htm))
18. Centers for Disease Control. (1996, July 19). Update: Outbreaks of *Cyclospora cayentanensis* Infection -- United States and Canada, 1996. *Morbidity and Mortality Weekly Report*, 45(28): 611-612. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/00043133.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00043133.htm)
19. Centers for Disease Control. (1997, May 30). - Update: Outbreaks of *Cyclosporiasis* -- United States, 1997. *Morbidity and Mortality Weekly Report*, 46(21): 461-462. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/00047716.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00047716.htm)
20. Centers for Disease Control. (1997, June 13). Update: Outbreaks of *Cyclosporiasis* -- United States and Canada, 1997 *Morbidity and Mortality Weekly Report*, 46(23): 521-523. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/00047875.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00047875.htm)
21. U.S. Department of Health and Human Services, U.S. Department of Agriculture. (1997, June 10). *Outbreaks of Cyclosporiasis and Guatemalan Raspberries* (FDA Talk Paper T97-22). Retrieved from: <http://www.cfsan.fda.gov/~lrd/tp raspbe.html>
22. US Food & Drug Administration - Center for Food Safety & Applied Nutrition. -*Foodborne Pathogenic Microorganisms and Natural Toxins Handbook*. (see selected outbreaks under Hepatitis A Virus) Retrieved from: [www.cfsan.fda.gov/~mow/chap31.html](http://www.cfsan.fda.gov/~mow/chap31.html)
23. Centers for Disease Control. (1997, April 4). *Hepatitis A* associated with consumption of frozen strawberries -- Michigan, March 1997. *Morbidity and Mortality Weekly Report*, 46(13): 288, 295. Retrieved from: [www.cdc.gov/mmwr/preview/mmwrhtml/00047129.htm](http://www.cdc.gov/mmwr/preview/mmwrhtml/00047129.htm)
24. American University School of International Services. (1997, March). Hepatitis A and Mexican Strawberries (TED Case Study #453). Retrieved from: [www.american.edu/TED/strwberr.htm](http://www.american.edu/TED/strwberr.htm)
25. GAPs Manual - Rangarajan, A., Bihn, E.A., Pritts, M.P. & Gravani, R.B. (2003). *Food Safety Begins on the Farm* (A Grower Self Assessment of Food Safety Risks). Ithaca, NY: Cornell University Department of Food Science, Department of Horticulture.



## New Mexico Chile Task Force Publication List

---

- Report 1:** An Industry-University Response to Global Competition
- Report 2:** Chile Seed Germination as Affected by Temperature and Salinity
- Report 3:** Yield and Quality of Machine-Harvested Red Chile Peppers
- Report 4:** Chile Seed Quality
- Report 5:** Guidelines for Chile Seed Crop Production
- Report 6:** Improving Chile Harvesting and Cleaning Technologies
- Report 7:** Farm Labor Employers' Handbook
- Report 8:** New Mexico's Chile Pepper Industry: Chile Types and Product Sourcing
- Report 9:** Economic Impact of Southern New Mexico Vegetable Production and Processing
- Report 10:** Chile Pepper Growers' Notes: 2003
- Report 11:** Developing New Marketing Strategies for the Southwestern Chile Industry
- Report 12:** Incidence of the Beet Leafhopper, *Circulifer tenellus* (Homoptera: Cicadellidae), in New Mexico Chile
- Report 13:** Plant Spacing/Plant Populations for Machine Harvest
- Report 14:** Economic Return to Adoption of Mechanical Thinning
- Report 15:** U.S. Imports and Exports of Chile Peppers and Pepper Products: Frequently Asked Questions
- Report 16:** International Trade in Chile Peppers: Data from the Global Trade Atlas
- Report 17:** Basic Research on the Use of Polarization to Sort Chile Peppers
- Report 18:** An Analysis of Farm Labor Contracting in New Mexico
- Report 19:** Use of Kaolin to Suppress Beet Curly Top Virus in Chile Peppers
- Report 20:** Using a Color Sorter to Remove Sticks from Mechanically Harvested Red Chile
- Report 21:** Regional Branding in a Global Marketplace
- Report 22:** Refinement and Testing of Mechanical Cleaners for Red Chile
- Report 23:** NMSU Crop Thinner Project: A Model for Commercialization of University Intellectual Property
- Report 24:** Chile Machine Harvesting Observations: 2004
- Report 25:** Design and Development of a Prototype Mechanical Gap Sorter for Mechanically Harvested Red Chile
- Report 26:** Good Agricultural Practices: What Growers Should Know

---

These publications also are available on the Web at:  
[www.chiletaskforce.org](http://www.chiletaskforce.org) and [cahe.nmsu.edu/pubs/taskforce/](http://cahe.nmsu.edu/pubs/taskforce/)

Printed April 2006

---

New Mexico State University is an equal opportunity/affirmative action employer and educator.  
NMSU and the U.S. Department of Agriculture cooperating.