Food

Environmental Assessment: Factors Potentially Contributing to the Contamination of Fresh Whole Cantaloupe Implicated in a Multi-State Outbreak of Salmonellosis

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This document provides an overview of FDA's findings and observations of factors that potentially contributed to the contamination of fresh, whole cantaloupe with the pathogen *Salmonella* Typhimurium and/or *Salmonella* Newport, which was implicated in a 2012 multi-state outbreak of salmonellosis.

Background

In August 2012, the Food and Drug Administration (FDA), in conjunction with the Centers for Disease Control and Prevention (CDC) and state health departments, began to investigate a multi-state outbreak of salmonellosis. *Salmonella* is a bacterium that causes the illness salmonellosis; it is composed of over 2,700 serotypes, all of which are presumed to be pathogenic. *Salmonella* has widespread occurrence in animals, especially in poultry and swine.

Based on epidemiological and product traceback investigational evidence, cantaloupes from Chamberlain Farms in the southwest region of Indiana were implicated in the outbreak. Additionally a cantaloupe sample collected at a retail location by the Kentucky Department of Public Health tested positive for *Salmonella* Typhimurium (0324) that was indistinguishable by pulsed-field gel electrophoresis (PFGE) analysis from the outbreak clinical isolates from ill patients associated with this foodborne illness outbreak. This cantaloupe sample traced back to Chamberlain Farms. The cantaloupes implicated in the outbreak were harvested from June 20, 2012 through August 16, 2012 and packed at a single on-farm packinghouse. The firm voluntarily stopped distribution of all cantaloupe and began removing all cantaloupe from the market on August 16, 2012. The firm also instituted a voluntary class I recall on August 24, 2012 for all cantaloupe distributed since harvest began on June 20, 2012 (total of 222,000 cantaloupes from 29 consignees in 8 states). The firm also began removing all watermelon from the market on September 6, 2012, based on a watermelon sample that tested positive for *Salmonella* Newport (0149). The positive watermelon sample was collected from a Chamberlain Farms field and analyzed by the Indiana State Department of Health (ISDH).

On August 14-31, 2012, FDA, along with ISDH officials, conducted a regulatory inspection at Chamberlain Farms during which FDA and ISDH observed growing, harvesting, and packing or holding of covered produce practices. FDA and ISDH also collected multiple samples, including whole cantaloupe and environmental (non-product) samples from within the packinghouse, for laboratory analysis to identify the presence or absence of *Salmonella*. Of the 70 environmental and product sub-samples collected from within the packinghouse, six were confirmed positive for *Salmonella* Newport (0807) with (PFGE) pattern combinations that were indistinguishable from one of the outbreak strains. Cantaloupe collected from the firm's fields during the inspection were confirmed positive for *Salmonella* Typhimurium (0324) and *Salmonella* Newport (0807) with PFGE

pattern combinations that were indistinguishable from the two outbreak strains isolated from ill patients.

In addition, the following conditions and/or practices were observed during the regulatory inspection conducted on August 14 - 31, 2012 of the Chamberlain Farms packinghouse. These conditions may have contributed to the *Salmonella* contamination and proliferation on cantaloupes:

Equipment Design:

- Food contact and non-food contact surfaces at Chamberlain Farms packinghouse were constructed of materials that could not be effectively cleaned or sanitized. These food contact surfaces had the potential to trap and harbor water, organic materials, and pathogens. Specifically, carpeting was used as cushioning and wood was used as directional mechanisms for conveyances.
- Multiple locations of the conveyer food contact surfaces used to transport cantaloupe, including rollers and belts, were noted to have an accumulation of organic materials and biofilms. Biofilms are possible harborages for pathogenic organisms such as *Salmonella*
- Changes and corrections to these noted conditions were made by Chamberlain Farms on site at the time of the investigation.

Packing and Holding:

- Written procedures or records were not available to demonstrate that water used in the cantaloupe packinghouse (i.e. dump tank and cantaloupe brush washing) was monitored for water disinfectant concentration or pH level to ensure the maintenance of an effective level of wash water disinfectant to prevent product-to-wash-water-to-product cross contamination. Submersion of warm melons in cool dump tank water may also have facilitated the infusion of dump tank water contaminated with *Salmonella* onto the cantaloupe via their stem scars or surface netting.
- An accumulation of debris including trash, wood, food pieces, standing water, mud, and dirt was observed beneath the conveyer belt in the cantaloupe packinghouse.
- Cantaloupes were not pre-cooled after packing before shipment to retail stores. Warm cantaloupe with rinds that have an increased water-activity (i.e., free residual moisture from washing procedures) and available nutrients from contact with insanitary food contact surfaces may have facilitated *Salmonella* survival and growth on the cantaloupe rind during subsequent holding.

As a result of the isolation of one of the outbreak strains of *Salmonella* in the packing environment (*S.* Newport 0807), and both outbreak strains on whole cantaloupes collected from production fields and storage, and a watermelon field sample, FDA initiated a second regulatory inspection in conjunction with ISDH that included an environmental assessment. FDA and State officials conducted the environmental assessment inspection at Chamberlain Farms on September 20-21, 2012. The environmental assessment inspection was conducted to gather more information to assist in identifying the factors that potentially contributed to the introduction, growth, or spread of the *Salmonella* strains that contaminated the cantaloupe. The firm cooperated in the environmental assessment inspection.

Epidemiology

According to the CDC, the final case count reported from 24 states was 261 persons infected with the outbreak strains of *Salmonella* Typhimurium (228 persons) and *Salmonella* Newport (33 persons). The number of infected persons identified in each state are as follows: Alabama (25), Arkansas (6), Florida (1), Georgia (13), Illinois (36), Indiana (30), Iowa (9), Kentucky (66), Maryland (1), Michigan (8), Minnesota (2), Mississippi (7), Missouri (17), Montana (1), New Jersey (2), North Carolina (5), Ohio (5), Oklahoma (1), Pennsylvania (2), South Carolina (4), Tennessee (8), Texas (2), Virginia (1), and Wisconsin (9).

Among 257 persons for whom information was available, illness onset dates ranged from July 6, 2012 to September 16, 2012. Ill persons ranged in age from less than one (1) year to 100 years, with a median age of 47 years. Fifty-five percent of ill persons were female. Among 163 persons

with available information, 84 (51%) reported being hospitalized. Three deaths were reported in Kentucky.

Environmental Assessment Inspection Team Approach

The environmental assessment was completed by a multi-disciplinary team with expertise in produce safety, agriculture, epidemiology, microbiology, environmental health, and sanitation from FDA and ISDH.

The team used Good Agricultural Practice (GAP) guidance and principles to develop hypotheses regarding potential routes for contamination of cantaloupe in the field. Areas of focus for the agricultural production operations included:

- agricultural water
- soil amendments
- harvesting and transporting to the packinghouse
- animal intrusion
- adjacent land use
- employee health and hygiene practices

Similarly, the team used GAP guidance and principles to develop hypotheses for potential routes of contamination during operations in the packinghouse area. Areas of focus for the packinghouse included:

- packinghouse and equipment sanitary design
- pest control/intrusion
- cleaning and sanitizing practices
- washing and drying of cantaloupes and watermelon
- cooling of cantaloupe and watermelon
- packing and holding of cantaloupe and watermelon
- transportation of cantaloupe and watermelon

The environmental assessment inspection included an in-depth interview with Chamberlain Farms management regarding their knowledge and implementation of food safety practices and procedures, as well as on-site visits to the cantaloupe and watermelon fields, packinghouse and holding areas, and included environmental non-commercial environmental product sampling. At the time of the environmental assessment inspection, no commercial cantaloupe or watermelon harvest or packing activities were in progress. However, the environmental assessment team visited cantaloupe and watermelon growing fields, the packinghouse and holding areas, and observed adjacent areas.

I. Factors Potentially Contributing to the Introduction, Growth, and Spread of *Salmonella*

A. Growing Environment

Environmental samples were collected in the cantaloupe and watermelon growing fields because of the presence of known and likely environmental sources of *Salmonella*. Environmental samples included soil, wild animal excreta, well water, pooling water on field perimeters, drainage ditch water, and cantaloupe. (See Table 1 for a complete list of confirmed *Salmonella* positive analytical results from the environmental assessment.) The following areas of the growing environment were observed and samples were collected during the environmental assessment: four fields used to grow cantaloupes for commercial harvest and adjacent land use, non-commercial cantaloupes (i.e., melons growing in the field after the field has been abandoned for the season and are not intended for harvest or introduction into commerce), and agricultural water wells.

1. Fields and Adjacent Land Use

There were four growing fields (Parcels A, B, C, D), all of which were located within an approximate three mile radius from the on-farm packinghouse and were planted with cantaloupe and/or watermelon in 2012. Of these four fields, one parcel was directly adjacent to a small show-cattle

farm. All fields had been stripped of vegetation prior to the EA, and evidence of drip tape, plastic mulch, melons, and corn husks from the previous year's crop were visible (no drip irrigation tape was found on Parcel A).

a. Parcel A was reported to have not been irrigated, and no sign of drip tape or a water source were observed. This parcel was divided in half with watermelons on the east side and cantaloupes on the west side. The landowner who leased the land parcel to Chamberlain Farms reported that there was no irrigation on the field in 2012. The entire field was traversed by the sampling team and soil samples were collected. The field exhibited signs of erosion and deer tracks; toads were also observed on the field. There was significant slope to the field leading down to a wooded border where a large pool of rainwater was present.

Sample Results: One sample with a total of six sub samples was collected from Parcel A. Four positive sub samples were detected with the following PFGE patterns:

- Positive soil sub samples
  - Outbreak associated PFGE pattern:
    - *S.* Newport (0807) 2 sub
  - Non-outbreak associated PFGE pattern:
    - *S.* Newport (0025) 1 sub
- Positive water sub sample (puddle)
  - Non-outbreak associated PFGE pattern:
    - *S.* Newport (0149) 1 sub

b. Parcel B was traversed, with signs of deer and coyotes, and a large number of toads. The field was surrounded by corn to one side, a county road on one side, a fallow field on one side, and Parcel C to the north. A privy and an irrigation outlet tied to the Cattle Well (for well information, see descriptions under "Agricultural Water Wells" section) were located on the border of the two parcels. There appeared to be no route of contamination from the adjacent cattle farm to this field other than the potential for cattle to escape the fencing and enter, although this was not observed nor reported during the time frame under investigation.

Sample Results: One sample with a total of eight sub samples was collected from Parcel B. Seven positive sub samples were detected with the following PFGE patterns:

- Positive soil sub samples
  - Non-outbreak associated PFGE pattern:
    - *S.* Anatum (0001) 2 subs
    - *S.* Newport (0149) 1 sub
    - *S.* Newport (4093) 1 sub
- Positive soil sub sample from adjacent cattle pasture
  - Non-outbreak associated PFGE pattern:
    - *S.* Anatum (0314) 1 sub
- Positive plant root sub sample
  - Non-outbreak associated PFGE pattern:
    - *S.* Anatum (0001) 1 sub
- Positive drip tape sub sample
  - Non-outbreak associated PFGE pattern:
    - *S.* Anatum (0033) 1 sub

c. Parcel C was surrounded by corn to the west, the border of Parcel B to the south, a county road to the east, and on the northern border, a field planted with soy beans. Standing water observed

along the northern border was sampled. Wildlife similar to Parcel B was observed. A dry ditch bordered the county road on the eastern side.

Sample Results: One sample with a total of seven sub samples was collected from Parcel C. Three positive *Salmonella* sub samples were detected with the following PFGE patterns:

- Positive soil sub samples
  - Non-outbreak associated PFGE pattern:
    - *S.* Anatum (0001) 1 sub
    - *S.* Anatum (0033) 1 sub
- Positive animal excreta sub sample
  - Non-outbreak associated PFGE pattern:
    - *S.* Typhimurium (1222) 1 sub

d. Parcel D was hilly with a high point in the middle. It was bordered by a wooded boundary on three sides, and a county road to the north. Non-commercial cantaloupes were still growing in the field and samples of cantaloupe were collected for analysis (See "Field Product – Non-Commercial Cantaloupe" below for sample results). There was evidence of significant erosion and washed-out areas following rainfall events earlier in the week. Wildlife evidence included deer tracks, toads, and coyote scat. Irrigation was provided by the water line supplied by the Large Well and the 525 W Wells. Three standpipes with spigots were located on the field.

Sample Results: One sample with a total of five sub samples was collected from Parcel D. A second sample of non-commercial cantaloupes was also collected from this field (See section I.A.2. Field Product). Three positive sub samples were detected with the following PFGE patterns:

- Positive soil sub samples
  - Non-outbreak associated PFGE pattern:
    - *S.* Anatum (0001) 1 sub
  - Outbreak associated PFGE patterns:
    - *S.* Newport (0807) 1 sub
    - *S.* Typhimurium (0324) 1 sub

e. A **fifth parcel** was used to discard culled melons from the packinghouse. This field was not investigated as product was not harvested from this field.

Sample Results: There were no samples taken from this field

2. Field Product – Non-Commercial Cantaloupe

Of the four discrete cantaloupe and watermelon growing fields that were visited during the environmental assessment inspection, only Parcel D still had cantaloupe (non-commercial) which could be collected and analyzed for the presence or absence of *Salmonella*.

Sample Results: One sample with a total of 10 sub samples was collected from Parcel D. One positive sub sample was detected with the following PFGE pattern:

- Positive non-commercial cantaloupe sub sample
  - Non-outbreak associated PFGE pattern:
    - *S.* Javiana (0419) 1 sub

3. Agricultural Water Wells

Five wells provided irrigation and packinghouse water, while a sixth served a greenhouse used to grow melon seedlings. The aquifer which supplies these water sources is approximately 36 feet below the surface and hence all wells are approximately 36 feet deep.

a. House Well – This well was located on the home and packinghouse property. It appeared properly developed and protected. Septic systems for the home and another for the office were

located greater than 150 feet from the well, an acceptable distance. There were no significant deficiencies.

b. Greenhouse Well – Located approximately 300 yards from the packinghouse. This well was not properly protected from contamination. The cap had openings to the outside and there was a depression at the base of the casing allowing water to pool. A large pipe from this well was previously used to irrigate a field across the street, but a separate pump for this was broken. A tee was present that would allow for connection of a hose but it was reported that it was not used to fill spray tanks. This well only serves greenhouse operations used to grow starter transplants.

c. Large Well – This well was located approximately ¼ mile west of the packinghouse and approximately 100 feet from Scott Ditch (a narrow, shallow, flowing man-made waterway located in a gulley about 15 feet deep, which discharges into the Wabash River several miles northwest). The large well provides water for the cantaloupe dump tank in the packinghouse and was interconnected with the 525 W wells to supply irrigation water to Parcel D (and potentially other fields planted in corn or soybean, not inspected during this environmental assessment). The well was open and was not protected against entrance of surface water contamination, animals, insects, or birds as the cap was broken, the wellhead covered by a plastic bucket that was also broken open, and the annular space of the well was not grouted. This well had a connection pipe for filling spray tanks and Mr. Chamberlain indicated it was occasionally used for this purpose.

d. 525 W Wells – These are two wells about 25 feet apart and 100 yards from a road. The two wells had electric wire entrances that were not sealed on top of the caps. The wells were interconnected so that water was pumped through the second well distribution pipe and discharged from the irrigation connection spigot.

e. Cattle Well – This well is on land owned by a neighboring landowner that is used as a small farm to raise about 30 show cattle. It appeared to be properly protected and water did not pool around the base of the casing. It was approximately 100 yards from the nearest cattle pasture. A shallow ditch ran in front of the pasture along the road. This well was used to irrigate the Parcels B and C at a spigot located at the border of these two adjacent fields.

f. Scott Ditch – The ditch is a narrow, shallow, flowing man-made waterway located in a gulley about 15 feet deep, which discharges into the Wabash River several miles northwest. It is located approximately 100 feet from the Large Well.

Sample results: Two samples with a total of six sub samples were collected from the wells and Scott Ditch. Six positive sub samples were detected with the following pathogens or enteric bacteria/fecal indicator:

- Positive Scott Ditch water (one sub with three positive results)
  - Non-outbreak associated PFGE pattern:
    - *S.* Group B, Monophasic (1364) 1 sub
  - Non-outbreak associated enteric bacteria/fecal indicator:
    - E. coli, 1 sub
    - Total coliform, 1 sub
- Positive well water sub samples (one sub sample from each of the five wells – only one sub sample for the 525 W well)
  - Non-outbreak associated enteric bacteria/fecal indicator:
    - *E. coli,* 5 subs
    - Total coliform, 5 subs

B. Packing and Holding

The following factors may have contributed to the introduction, growth, or spread of *Salmonella* contamination: packinghouse design, equipment design, and packing or holding practices.

1. Packinghouse Design

Certain aspects of the packinghouse, including use of water in the packing operations, may have facilitated the spread of *Salmonella* from food contact and non-food contact surfaces to the cantaloupe.

The following conditions and/or practices were observed and may have contributed to the *Salmonella* contamination of cantaloupes:

- Packinghouse design allowed for the pooling of water on the packinghouse floor adjacent to equipment.
- The packinghouse floor was constructed in a manner that was not amenable to cleaning.
- Harborages existed in the packinghouse structures. There was evidence of birds roosting in the open rafters, including bird droppings. Bird droppings were also noted on the equipment and floor below the rafters. The rafters where birds had roosted were directly above food contact surfaces (e.g., brush rollers, conveyor belts, grading table), or directly above product during conveyance, grading, and sorting.
- The drip-line of the packinghouse roof extends over the conveyor belt and brush washer; hence rain water and related roof debris were likely to have run-off from the roof on to food contact surfaces.

2. Equipment Design

FDA evaluated the design of the equipment used in the packinghouse to identify factors that may have contributed to the growth or spread of *Salmonella*. The design of the packinghouse equipment, including that it was not easily amenable to cleaning and sanitizing and that it contained visible product and filth buildup, is a factor that likely contributed to the introduction, growth, or spread of *Salmonella*.

The following conditions and/or practices were observed and may have contributed to the *Salmonella* contamination of cantaloupes and/or *Salmonella* survival or growth:

- The packing equipment was not easily cleaned and sanitized as it was constructed of uncleanable and unsanitizable food contact surfaces.
- The cantaloupe packing and brush washing equipment had sanitary design flaws similar to equipment previously associated with cantaloupe-related foodborne illness outbreaks.
- The packinghouse operation equipment contained visible product and filth buildup, and visible signs of corrosion.

An environmental sample collected from the watermelon packing line (which was not in operation at the time of the environmental assessment) tested positive for *Salmonella* Newport with PFGE pattern combinations that did not match either of the outbreak strains. Bird droppings were observed in the area of the watermelon packing line.

Sample Results: One sample with a total of nine sub samples was collected from the packinghouse. One positive sub sample was detected with the following PFGE pattern:

- Positive packinghouse sub sample
  - Non-outbreak associated PFGE pattern:
    - *S.* Newport (0005) 1 sub

3. Packing and Holding Practices

Free moisture or increased water activity on the cantaloupe rind from washing procedures during packing may have facilitated subsequent *Salmonella* survival and growth during storage and transport. Cantaloupe that is washed and packed on unsanitary food contact surfaces could be contaminated with *Salmonella* or could collect nutrients for *Salmonella* to persist on the cantaloupe rind. Wet fruit, packed still warm with field heat, potentially created conditions that would allow for *Salmonella* persistence and possible growth. The combined factors of the availability of nutrients on the cantaloupe rind, increased rind water activity, and lack of any cooling may have provided ideal

conditions for *Salmonella* to survive or grow.

The following conditions and/or practices were observed and may have contributed to the *Salmonella* contamination of cantaloupes:

- The firm did not pre-cool the cantaloupes (remove field heat) before storing and shipping.
- Cantaloupes were packed while still moist from washing on the packing line.
- The firm failed to implement cleaning and sanitizing procedures in the packinghouse to protect against food contamination.
- The firm did not adequately monitor or control wash water disinfectant levels to control, reduce or prevent the potential for cross contamination; nor did the firm maintain record books of the same.
- The firm failed to empty garbage receptacles, resulting in a harborage area for pests.

II. Discussion

Based on the positive test results from the environmental samples collected from the Chamberlain Farms production fields and packinghouse during two separate FDA investigations, it is likely that the initial contamination of the melons occurred in the production fields and was spread by operations and practices within the packinghouse. It is also likely that the contamination proliferated during storage and transport to market.

FDA has identified the following factors in the growing environment and the packinghouse that most likely contributed to the contamination of fresh, whole cantaloupe with the pathogen *Salmonella*:

A. Growing Environment:

Findings of multiple pathogenic *Salmonella* serovars prevalent throughout the agricultural environment and incoming cantaloupe likely significantly contributed to the introduction of the pathogen on to cantaloupe and into the packinghouse. It is significant that soil and water environmental samples collected in all growing fields, and remaining cantaloupe collected in one field, tested positive for multiple *Salmonella* serovars, including some that were indistinguishable from the two outbreak strains through laboratory analysis. It is important to note that the growing fields were the primary and most likely means of initial cantaloupe contamination. Specifically, *Salmonella* contamination of incoming cantaloupe from the agricultural environment may have allowed for the establishment of a harborage or niche for *Salmonella* in the packing and storage operations.

Because the samples collected from agricultural water sources were negative for *Salmonella,* agricultural water used for irrigation, crop protection sprays, and in the packinghouse were not a likely route for introducing *Salmonella*. However, FDA has determined that the agricultural water used during the growing, harvesting, and packing or holding of cantaloupe at Chamberlain Farms may not have been of adequate quality, and therefore cannot be eliminated as a potential contributor in the spread of *Salmonella* contamination. Specifically, while water may not have been the primary source of *Salmonella* contamination in the growing, harvesting, and packing or holding environments, use of agricultural water in these operations may have acted as a vehicle to spread contamination, once introduced.

Some possible sources and routes of contamination, based on hypotheses devolved after considering the observations made and on the current thinking of the FDA as put forth in various guidance documents[1, 2] may include (in no particular order):

- Biological soil amendments may have been the source of the pathogen; however, Chamberlain Farms reported that the firm does not use any biological soil amendments for the production of cantaloupes or watermelons. It is unclear if adjacent or previous land use may have played a role in this. It was noted by the EA team that significant poultry (turkey) production is located in the local region of Chamberlain Farms.
- Additionally, it was hypothesized that agricultural water may have been a vehicle for the

spread of contamination. Chamberlain Farms did report that subsurface drip irrigation was used on three of the four fields visited during the EA. However, Chamberlain Farms reported that they did not use any irrigation water for the production of cantaloupe or watermelons on Parcel A (a parcel where, both watermelon (collected by ISDH) and soil samples (collected by FDA) were found to be positive for *Salmonella*). This is extraordinary given the water use demands typically required to commercially produce cantaloupe and watermelon, particularly given the extreme heat and drought conditions which occurred in Southwest Indiana during the summer growing season of 2012.

- Although none of the wells tested positive for *Salmonella*, it is interesting to note the positive findings of generic *E. coli* and total coliform. While the *E. coli* and total coliform are not pathogenic, nor are they necessary indicators of the presence of *Salmonella*, it is unusual to note indicators of fecal contamination to be recovered from ground water sources. It was reported to FDA that the local aquifer is very shallow (30-40ft) and subsequently all wells are dug only to this depth. This is of interest for the following reasons:
  - Due to the location of the Large Well to Scott Ditch (dug to 15ft), which did test positive for *Salmonella*, *E. coli*, and total coliform, it is possible that Scott Ditch is influencing the aquifer at the location of the Large Well.
  - The observations from the EA team that some of the wells were poorly constructed, or were in disrepair, suggests they may have been subject to contamination by run-off, or through subsurface influences.
- The combined information listed above supports the hypothesis that agricultural water may have been a contributing factor.

B. Packing and Holding:

The design of the packinghouse – which included separate watermelon and cantaloupe packing lines – and design of the equipment, including equipment used to wash the cantaloupe, did not lend itself to being easily or routinely cleaned and sanitized. Several areas on both the washing and drying equipment appeared to be uncleanable, and dirt and product buildup was visible on some areas of the equipment. In addition, wet environments are known to be potential reservoirs for *Salmonella* and the pooling of water in close proximity to packing equipment, including conveyors, may have extended and spread the pathogen to food contact surfaces. Therefore, this aspect of the packinghouse design is a factor that may have contributed to the introduction, growth, or spread of *Salmonella*. This pathogen is likely to establish niches and harborages on uncleanable food contact surfaces and other areas where water pools or accumulates. Furthermore, cantaloupe that is washed and packed on unsanitary food contact surfaces could be contaminated with *Salmonella* or could collect nutrients for *Salmonella* to persist on the cantaloupe rind. Wet fruit packed still warm with field heat may have potentially created conditions that would allow for *Salmonella* persistence and possible growth. The combined factors of the availability of nutrients on the cantaloupe rind, increased rind water activity, and lack of cooling may have provided ideal conditions for *Salmonella* to survive or grow.

III. Recommendations for Prevention of *Salmonella* Contamination Based on these Findings

Fruit and vegetable producers should employ good agricultural and management practices recommended for the growing, harvesting, washing, sorting, packing, storing, and transporting of fruits and vegetables sold to consumers in an unprocessed or minimally processed raw form. These practices are set forth primarily in FDA and USDA's "Guidance for Industry -- Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables.[1]" FDA's "Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards of Melons; Draft Guidance[2]" and "Guidance for Industry: Letter to Firms that Grow, Harvest, Sort, Pack, Process, or Ship Fresh Cantaloupe[3]" provides additional information relevant to preventing contamination of cantaloupe with human pathogens.

FDA's findings regarding this particular outbreak highlight the importance for the industry to

employ good agricultural and management practices in their packinghouses as well as in growing fields. Specifically, FDA recommends that firms take the following steps in the growing environment:

- Assess produce growing practices and procedures to control, reduce or eliminate the introduction of *Salmonella* and other pathogens into the agricultural environment where fresh produce is grown.
- Growers should follow good agricultural practices for handling animal manure to reduce the introduction of microbial hazards to produce. Such practices include processes such as composting that are designed to reduce possible levels of pathogens in manure. Good agricultural practices may also include minimizing direct or indirect manure-to-produce contact.[1]
- Growers may consider scheduling application of raw manure on adjacent fields to maximize the time between manure application to those fields and harvest of produce. Growers may also consider establishing field plans where the fields closest to produce crops are planted with crops that do not receive raw manure.[1]
- Consider barriers or physical containment to secure manure storage or treatment areas where contamination from runoff, leaching, or wind spread is a concern.[1]

FDA recommends that firms take the following steps in the packing and holding environment:

- Assess produce packinghouse and equipment design to ensure adequately cleanable surfaces and eliminate opportunities for introduction, growth, and spread of *Salmonella* and other pathogens.
- Ensure that water is of sufficient microbial quality for its intended use. Using dump tank water with sufficient water disinfectant present and monitoring the levels to reduce the potential risk of cross-contamination. Note: The primary purpose of the water disinfectant is not to clean the melons but rather to prevent the water from becoming contaminated should pathogens be introduced into the water from melons. The contaminated water could then act as a source of contamination for incoming melons.[2]
- Assess and minimize opportunities for introduction of *Salmonella* and other pathogens in packinghouses.
- Implement regular cleaning and sanitizing procedures.[1,2]
- Verify the efficacy of cleaning and sanitizing procedures.
- Periodically evaluate the processes and equipment used in packing operations to assure they do not contribute to fresh produce contamination.
- Implementing melon handling operations that minimize the incidence of melon surface moisture to reduce potential plant and human pathogen growth. Cooling and cold storing melons as soon as possible after harvest, if melons are to be air cooled.[2]
- Developing and maintaining written food safety plans and SOPs for areas such as handling and storage practices, field, facility and vehicle cleaning and sanitation, and employee training programs.[2]
- Maintaining records for significant activities performed, such as monitoring of water sources and use; testing water quality; treating water; monitoring for signs of animal intrusion; cleaning and sanitation of equipment, containers, and vehicles; employee training; and corrective actions taken.[2]
- Recording information such as the date and time, name of person(s) who completed the record, the location of the field and location in the field, if applicable, and the activity being monitored in the documentation.[2]
- Growers should further consider the recommendations put forth in FDA's Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards for Fresh Produce and Vegetables[1] and FDA's Draft Guidance for Industry: Guide to Minimizing Microbial Food Safety Hazards of Melons.[2]

Table 1. Samples collected during the environmental assessment: Confirmed *Salmonella*

positive analytical results by sample location, serotype and PFGE pattern.

Serotype-Pattern/Location	Parcel A	Parcel B	Parcel C	Parcel D	Scott Ditch	Packing House	Product Sample
JAGX01.0001 Anatum		2 Soil subs (2, 5); 1 Plant Root sub (6)	1 Soil sub (2)	1 Soil sub (2)			
JAGX01.0033 Anatum		1 Drip Tape sub (7)	1 Soil sub (5)				
JAGX01.0314 Anatum		1 Soil sub: Cattle Pasture (8)					
JJPX01.0005 Newport						1 swab (8)	
JJPX01.0025 Newport	1 Soil sub (4)						
JJPXX01.0149 Newport	1 Water (puddle) sub (6)	1 Soil sub					
JJPX01.0807 Newport*	2 Soil subs (1,3)			1 Soil sub (4)			
JJPX01.4093 Newport		1 Soil sub (3)					
JJPXX01.0324 Typhimurium*				1 Soil sub (5)			
JPXX01.1222 Typhimurium			1 Animal Excreta sub (6)				
JPXX01.1364 Group B, monophasic					1 Water sub (2)		
JGGX01.0419 Javiana							1 sub (2)

*** Denotes outbreak strain**

(n) represents sub sample number

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[1] FDA Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables[1]

[2] Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards of Melons; Draft Guidance[2]

[3] Guidance for Industry: Letter to Firms that Grow, Harvest, Sort, Pack, Process, or Ship Fresh Cantaloupe[3]

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