Addressing Animal Manure Management Issues for Fresh Vegetable Production

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Animal waste pollution and the application of animal manure to production soil are two critical issues of concern in the preharvest and postharvest microbial food safety management of fresh vegetables. Indirectly through contaminated water or by direct cross-contamination from inadequately composted animal manure, there exists a potential hazard for persistent pathogen populations on harvested crops. Arguably, leafy vegetables that are consumed without cooking represent a higher level of consumer risk than many other crops. Postharvest operations of trimming, washing, and blending for salad mix products has the potential to amplify this risk. Though direct evidence of food-associated illness due to contamination of leafy greens during commercial production is scant, compelling epidemiological linkage to these fresh vegetables has implicated poor production practices, with regard to animal waste or manure, in direct contamination. This article presents some highlights of work-in-progress by a multidisciplinary research and extension group at UC Davis(Drs. D. Cliver and H. Rieman, Veterinary Sciences: Population Health and Reproductive Biology, D. Meyer, Animal Sciences; Waste Management Specialist and T.Suslow, Dept. of Vegetable Crops) to develop needed information on industry practices, pathogen persistence, and pathogen reduction practices for manure intended for vegetable farm or direct crop applications.

Background

Annually, animal waste production in the United States exceeds 100 times the volume of human waste. Animal production operations are increasingly concentrated and very large dairy operations are characteristic in California. Producing greater quantities of manure in smaller areas increases the difficulty of fully utilizing the material for bedding, on-site land application and off-site farm distribution. The estimated annual US manure production exceeds one billion tons. Dairy and cattle production facilities are the largest contributors and may seasonally be sources of *Salmonella, E. coli* O157:H7, *Cryptosporidium*, and other potential human pathogens. The risk of water pollution and contamination from waste spills, runoff, seasonal flooding, and lagoon leakage is increased. Health officials, at a recent national food safety meeting disclosed preliminary data, which demonstrate that

foodborne illness associated with fresh produce in the US aligns predominantly with pathogens of animal origin. Illness attributed to imported produce predominantly aligns with human sources. Industry, government and academia are continuing to work towards broader implementation of existing Best Management Practices and innovating new, science-based solutions to both pathogen and waste reduction practices.

Predictive information on the persistence of key pathogens in aged, stacked dairy and cattle manure, a common handling method, is generally lacking. Limited Time:Temperature studies of *Salmonella* and *E. coli* survival in stacked piles support the effectiveness of current managed composting practices. Natural or artificially inoculated manure exposed to a temperature range of 45 to 50°C eliminates detectable populations in less than three weeks.

Research-in-Progress

In practice, detectable populations of nonpathogenic *E. coli*, indicators of survival potential, are found in stored stacked manure piles and field-side piles prior to spreading. Populations range from less than 100 to greater than 1,000,000 viable bacteria per gram and may be detected in manure over a broad range of collection-point temperatures (Figures 1 and 2). Temperatures below the surface of manure piles can exceed 65°C while a layer just under the surface may be below 35°C. Overwintering piles may harbor high populations of these E. coli. Preliminary model studies with *E. coli* O157:H7 and *Salmonella typhimurium*, led by team member H. Riemann, predict a survival period exceeding 100 days from a starting population of one million cells in both chicken and dairy manure. Water activity, pH, ammonia concentrations, microbial activity and other factors affect the rate of lost of viability in stacked piles.

Transfer to Crops Soil

Manure is predominantly applied to vegetable production ground in the fall, prior to seeding or transplanting, at rates typically ranging from 4 to 6 tons/acre. Some intensive, small-scale vegetable operations use almost double this amount. Although generally avoided, surviving populations in field-stored piles represent an undetermined risk if placed adjacent to existing crops.

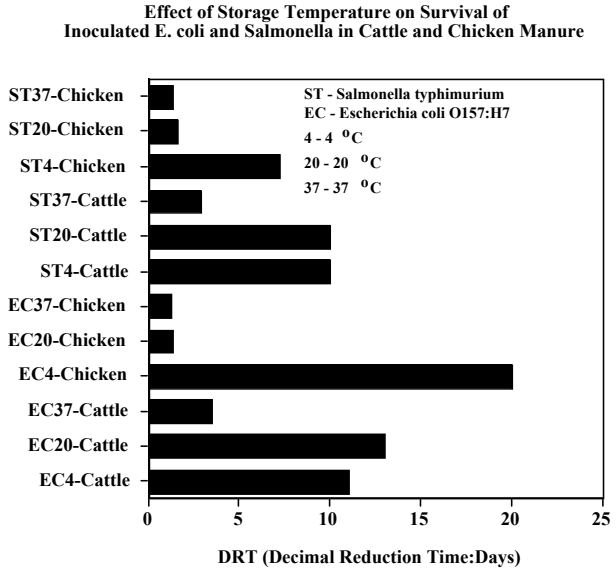

Figure 1. *Laboratory studies establish predicted time to achieve a single decimal reduction (10-fold or 90%) in viable populations of inoculated bacteria in fresh cattle or chicken manure. Surveys of stacked cattle manure in California have detected populations of non-pathogenic* E. coli *as high as 10^9 CFU/gm in pile-zones with temperatures below 37°C. If model studies are predictive, it could require at least 48 days to reach non-detectable levels.*

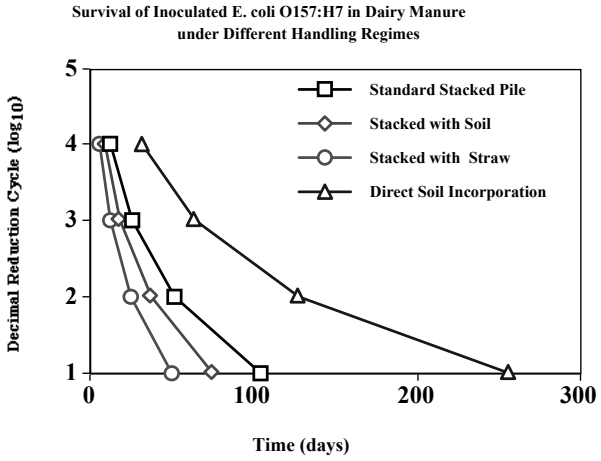

Figure 2. *In model laboratory studies, the time required to achieve four cycles of a decimal (10-fold) reduction in starting populations of* E. coli *O157:H7 inoculated into fresh dairy manure is impacted by handling methods. Incorporated directly in Yolo loamy clay soil maintained near Field Moisture Capacity is predicted to require approximately 278 days to reach a 99.99% loss of viability.*

Once incorporated into soil, current experimental models for *E. coli* O157:H7 predict a period of 60 to120 days for a 99% loss of viable populations depending on soil type, matric potential and other factors yet to be determined. In parallel field studies over a two-year period, generic *E. coli* was not

detectable during the planting season following soil incorporation of manure (*E. coli* was detectable at the time of incorporation) during the fall in coastal California vegetable fields (R. Smith, personal communication). Within the limits of the sampling and detection methodology, no *E. coli* were detectable in 20 soils and associated vegetable crops.

In establishing company Good Agricultural Practices, farming operations have minimized the transfer potential of residual pathogen populations in field-side manure piles or windrows by using tarps or other sturdy coverings. Instituting this standard management practice eliminated the detection of generic *E. coli* on immediately adjacent crops (personal communication).

Water

During the limited sample surveys we have conducted, irrigation water was identified as one source of potential manure, compost pile and crop contamination. Generic *E. coli* were detected in several source water samples near piles of dairy manure used for application to vegetable production soil. At this time, the animal waste management specialists generally recommend the following separation distances from water sources:

- Wells -200 feet
- Surface water - at least 100 feet for sandy soil and 200 feet for loamy or clay soil (slope less than 6% increase distance to 300 feet if slope greater than 6%)

No documented information is available to quantify the volume, distribution, handling and application practices among conventional and organic vegetable producers in California. D. Meyer is leading the effort to obtain this survey information during summer 1999.

Manure-teas

Special attention to the practice of applying manure slurries or "teas" to existing crops deserves mention. Manure enriched brews of various composition have been used by growers and home gardeners around the world for many years for fertility management and disease control. Domestically, the extent of use on fresh vegetables is unclear but the practice does occur. At this time, I have not seen the numerous sources of instructional information on manure tea preparation and use accompanied by any cautions regarding human food safety. Typical preparation calls for the use of "raw" or aged manure in a 55-gallon drum (1:4 manure to water). After 2 to 3 weeks, a strained tea or slurry is applied to soil or sprayed on foliage. The strained solids are applied to green waste compost piles. Studies thus far, again led by H. Riemann, have determined a period of at least 10 days to greater than 70 days for the destruction of *E. coli* O157:H7 and *S. typhimurium* in liquid manure slurries held at temperatures between 4°C and 20°C. Research by others strongly suggests that mixing other organic components (generally plant origin) into the steeping drum water will increase the survival potential of *E. coli* O157:H7. Other potential pathogens and parasites may survive the incubation period for manure tea. A greater effort at risk assessment of this practice, though not generally welcomed by practitioners, seems well justified.

Summary Considerations

- In the absence of adequate turning, stacked and aged manure piles should be monitored for adequate temperature gain.
- Consideration should be given to monitoring for elimination of residual populations of indicator, generic *E. coli* (not total or fecal coliform counts).
- Equipment and worker flow between manure handling or spreading operations and crop management or harvest and packing operations must be evaluated from a food safety perspective.
- Adequate separation of stored manure and water sources used for edible crop irrigation or postharvest handling should be determined and maintained.
- Proper water disinfection practices must be determined and maintained, especially in higher risk water source conditions.

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