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The Science and Art of Quality and Safety

Eliminate "Fecal Coliforms" From Your Vegetable and Fruit Safety Vocabulary

(NOTE: *This extension article was first prepared in 2002 and has been modified and updated as it is still providing useful background information in designing and defending produce safety programs. At this time, this extension note will not include information or reference to the FSMA Produce Safety rule in relation to fecal indictors and water quality standards.*)

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What a difference a name makes!

When talking about Good Agricultural Practices (GAPs), food safety management and certification plans, or Total Maximum Daily Loads (TMDLs) in ag-runoff water, developing fruit and vegetable microbial standards or setting regional water policy, total numbers of **coliform** bacteria or **fecal coliforms** is generally not indicative of risk of actual fecal contamination. Extensive studies conducted in horticultural production environments have repeatedly shown these bacterial groups provide limited reliability in indicating the likelihood of pathogen presence when applied to these sample sources. Though still pervasive in microbial safety standards associated with the above applications, basing risk policy and risk management decisions on these bacterial groups assumes a direct link to fecal contamination and the presence of human pathogens—an assumption not supported by current science. The potentially misplaced concern for water or fresh produce to be contaminated remains a significant source of confusion and knee-jerk reactions. The figure below may be helpful in learning that diverse groups of bacteria that give a positive fecal coliform result contain non-fecal coliforms. In addition, under some test conditions, explained below, non-enteric and non-coliform bacteria can give a positive reaction and would be included in counts against a regulatory or nonregulatory limit.

Nonpathogenic *Escherichia coli* (*E. coli*) and some pathogenic and toxigenic *E. coli* would give a positive reaction but one serious pathogenic *E.coli* does not. Some important pathogens, such as *Salmonella* and *Shigella,* are part of a broader related group, total enteric bacteria (enteric = found in the intestines), but do not give a positive result in standard tests for identifying coliforms and fecal coliforms.

Who cares?

You should. Current methods and terminologies of establishing actions based on general and presumed fecal indicator bacteria are affecting your farming operations and can challenge your ability to market your crop and may impact your bottom-line.

These general terms for a large and diverse class of bacteria are useful and remain relevant in specific food, wastewater management, water quality applications, and other process controls following specific antimicrobial treatments; however, they have limited or no useful meaning in describing quality or safety attributes of edible horticultural commodities and value-added produce. For the sake of brevity, let's focus on the bigger hot-button: fecal coliforms.

Fecal coliforms are a historical group of indicator bacteria that may be associated with and colonize in the intestinal tract. Some are clearly of fecal origin but they are also closely related to common plant shoot, root, flower, and fruit colonizers sharing the same taxonomic classification (scientific naming system). The overlap between fecal and non-fecal sources includes bacteria such as *Enterobacter, Citrobacter, Klebsiella* and a diverse group of soil and plant residents with equally obscure names. Some plant pathogens may be included in this group when the standard culture-based indicator tests are conducted at too low a temperature, which is unfortunately very common in testing labs.

The common gut-colonizer *E.coli*, generally recognized as benign, as well as dangerous human toxin-producing *E.coli* pathogens are within the fecal coliform group. One you may have heard about in connection with very serious illness and death in numerous outbreaks, *E.coli* O157:H7, belongs to this group but doesn't give the expected diagnostic reaction in standard tests. As the group name implies, microbiologists who developed the original techniques determined a strong association of fecal contamination in certain applications including dairy products, drinking water, composted manure, biosolids, and treated sewage effluent. In practice, a positive result implies a clear potential of harboring bacteria of known residence in the gastrointestinal tracts of humans and animals and fecal contamination. From these taxonomic clusters, they developed the positive association of groups of bacteria with common visual traits or biochemical reaction in simple, rapid and uniform lab tests.

What is the problem?

The problem is that this association doesn't seem to hold up when evaluating typical irrigation water, run-off water, or fresh produce safety. To be a useful indicator of hygienic standards and water management decisions, the following assumptions must be true for fecal coliforms in each setting or application where samples are collected and analyzed against a standard or microbiological acceptance criteria;
1) The only direct or indirect source of these bacteria is feces, manure, septic run-off, or sewage.
2) There is no significant source in the environment unrelated to these primary sources.
3) The indicator bacteria do not multiply in soil, water, and especially do not multiply significantly on the surface of crops, surrounding vegetation or rangeland plants.

Research over many years and in many regions has shown that the current, general grouping called 'fecal coliforms' most often fails in each of these assumptions when talking about horticultural commodities and typical crop management water sources under the influence of run-off from production locations. There are known exceptions where both point-source (e.g. an animal feeding operation) or non-point source (e.g. environmental run-off from areas with high density wildlife) can lead to an impaired water source. The predominant numbers of bacteria that test positive in assays for fecal coliform may be *E. coli*, but from horticultural production and postharvest handling operations the greater numbers are often benign or non-pathogenic soil and leaf colonizers. Like true fecal coliforms, some of these soil and plant associated bacteria can grow well at 112°F (44.5°C), the temperature used in detection procedures. We use the term "thermotolerant coliforms" (grows at this higher than human body temperature) to get away from the presumed connection to fecal contamination. The numbers of thermotolerant coliforms' is highly variable and readily influenced by climate, weather, water source, farm inputs, plant growth habitat and developmental stage, and crop management practices.

A much bigger problem is that standard fecal coliform tests used by most service labs, based on a test developer's labeled instructions, use much lower temperatures of incubation, 95 to 98.6°F (35 to 37°C). At these temperatures, many coliform bacteria will grow and produce the characteristic visual appearance or biochemical reaction. The problem here is that high numbers of false fecal indicators are recorded in a grower report or product test conducted by a buyer on received product. Ideally, your testing lab should use the higher incubation temperatures to improve accuracy. It is especially important if you are being held to specific numeric limits for fecal coliforms and *E. coli* product acceptance.

What are the consequences?

1) Uninformed individuals see high numbers of "fecal" bacteria from produce or water samples and assume the grower's fruit or vegetable is not marketable.
2) Some GAP and food safety planners and auditors erect impractical and unnecessary standards for microbial content.
3) Some service providers use the data to sell unnecessary and often ineffective sanitation and process control systems that provide no assurance of freedom from true pathogen contamination.
4) Ag-water use and management policies may be developed without the benefit of a sound risk assessment.

What indicator is best?

Monitoring for pathogens is impractical due to very low prevalence and high cost. As a result, the sensible longstanding approach has been to use scientifically valid indicators, such as *E. coli,* to characterize the potential for fecal contamination in fresh water sources and on produce. The Environmental Protection Agency (EPA) cites *E. coli* as the best indicator of microbial water quality in recreational freshwater systems. The EPA levels are not strictly applicable to developing irrigation water standards but serve as useful guidance for current research and practical approaches to on-farm food safety system development. Non-pathogenic *E. coli* demonstrate many of the “Recommended Indicator” traits listed above and the cost of monitoring is not prohibitive for most growers and shippers. Unfortunately, several years of research has shown that the predictive correlation between *E. coli* and the presence of human pathogens, including viruses and parasites, is highly inconsistent or entirely lacking in many applications for fruit and vegetable production and postharvest handling. In addition, recent reports have found that *E. coli* has the ability to multiply in water and soil in tropical and sub-tropical production environments thereby mistakenly elevating the apparent risk and concern. Short-term growth in warmer temperature regions is also possible if soil or water nutrient levels are high. **However, it is still the best we have for now.**

Other promising indicators, such as other true fecal bacteria or viruses of *E. coli*, persist much longer in the environment than many pathogens. Finding alternative indicators and rapid diagnostics for on-farm measurements is an active area of research at many institutions and technology development industries.

How should *E. coli* data be used?

If you choose or are required to establish on-going microbial monitoring, the first essential step is to develop and implement a GAPs program and a broader food safety management system to minimize the likelihood of pathogen contamination and survival. Second, within the establishment of the GAPs program, develop a baseline of data, over time, to identify what should generally be expected for surface water and on harvested crops. There are several closely related schemes described in produce industry guidance and standards. The way tests are done, both thermotolerant coliforms and *E. coli* population estimates are determined from the same sample unit and assay. *E. coli* in well (ground) water would not be expected and its presence should trigger further evaluation and treatment. The third step, and not necessarily the last, is to determine the locations and frequency of routine monitoring to test for significant variance from the indicator limits you are subject to or have chosen to follow. If a non-compliant result or trend is obtained, follow the described corrective measure or corrective action associated with the standard. Developing a corrective action plan is not always simple and may require input from a qualified professional to arrive at the most practical and economic approach.

Fig. 1 – In standard microbiological testing from horticultural production and postharvest handling environments, counts of total coliform or fecal coliform bacteria are poor indicators of quality or safety. Presence/absence tests or counts of generic *E. coli* in water or on fresh produce are poor indicators of fecal contamination and worse predictors of pathogen presence, but it is the best we have for now.