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Reducing Risks from *E.coli* 0157 on the Organic Farm

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Summary

E. coli 0157 is a bacterial pathogen of the human intestinal tract which is carried in certain species of livestock and wildlife without ill-effect. Such organisms are termed zoonotics. Various types of *Campylobacter* and *Salmonella* are other major causes of food borne illness that like *E. coli* 0157, are zoonotic in livestock and appear to have been on the increase in recent decades. *E.coli* 0157 is particularly hazardous because of the very low number of organisms that can cause infection and because of serious complications that can result from infection, especially in infants and the elderly. As well as from contaminated food, *E. coli* 0157 can be acquired through casual contact with manure and with fecal contaminated surfaces and water. Thus farm residents and workers should be aware of the nature of *E. coli* 0157 and of personal measures they can take to reduce the risk of infection. Reducing the levels of zoonotics in farm animals is seen as a key component of strategies to reduce the occurrence of food borne infections generally. A number of the existing practices of organic farming could be expected to discriminate against *E. coli* 0157. However, none can ensure its absence and the routes by which 0157 moves into farms apply to organic farms, for example via birds that have been feeding on a farm with a high level of *E. coli* 0157. Some provisional guidelines for reducing levels of *E. coli* 0157 on organic farms and the risk to farm workers and residents are offered. They are pertinent also to gardeners who use manure or buy bulk compost.

CONTENTS

INTRODUCTION

The occurrence of human pathogens in livestock and livestock manure is a concern to livestock farmers, to stockless farmers who use manure as a soil amendment, and to all of us as consumers. Of increasing notoriety is a nasty bug known as *Escherichia coli* 0157:H7, which I will call 0157 for short. Dennis

Avery, the perennial critic of organic farming contends that organic produce is more likely than conventional produce to carry this and other harmful bugs because of the use of manure on organic produce (1). Aside from failing to present any comparative data to support his argument, he chooses to overlook some key facets of organic production- such as the requirement to compost or age manure - that could be expected to make it much less susceptible to carrying pathogens than systems that do not have such requirements. Regardless, it is an issue that the organic community must take seriously, both to battle the perception that organic could be more susceptible to food poisoning, and to ensure that is not the case. One big factor we have going for us is that as a result of certification, "organic" is a well defined system and a structure is in place for disseminating information, and as necessary, ensuring that prescribed practices are followed.

This article examines some of what is known or suspected about the occurrence and survival of 0157 on farms and in produce and its relevance to organic farming. Research into the epidemiology and prevention of 0157 on the farm is just beginning, thus mostly what can be offered in the way of prevention are guidelines that apply to prevention of spread of food borne zoonotics generally. Zoonotics are organisms that exist naturally and usually without ill effect in animals and can be transmitted to humans under natural conditions, causing disease. Various types of *Campylobacter* and *Salmonella* are other major causes of food borne illness that are also zoonotics in farm animals, and like 0157 have been on the rise in the last 20 years (2).

What is *E.coli* 0157?

E. coli is a normal inhabitant in the intestine of humans and animals. The number of *E. coli* in a sample of water is a commonly used indicator of fecal contamination. A minority of the strains are pathogenic including 0157, which produces a "vero" or "Shiga" toxin which breaks down the lining of our intestines and can damage kidneys. Symptoms are bloody diarrhea and abdominal cramps (or sometimes non-bloody diarrhea or no symptoms at all). Usually little or no fever is present, and the illness dissipates in 5 to 10 days. A more serious complication called hemolytic-uremic syndrome (HUS) can lead to kidney failure and death; it occurs mostly in children under 5 and the elderly. The Center for Disease Control in the U.S. suggests that anyone having sudden diarrhea with blood should get their stool tested for O157. It is estimated to affect 73,000 people and cause 61 deaths each year in the U.S. (3). In many regions of Canada, 0157 is the second most common bacterial pathogen in stool specimens submitted to clinical laboratories (first is Campylobacter), moving into first place during warmer months. 75-90 episodes of HUS occur in Canada each year, most of them between April and September (4).

Most 0157 infections have been associated with eating undercooked ground beef which was contaminated through contact with feces in slaughterhouses. However, infections have also resulted from ingesting 0157 in water and other foods, (3, 5) including

- reservoir and recreational water
- raw milk
- unpasteurized apple juice/cider
- sandwiches
- lettuce
- dry cured salami

- produce from manure-fertilized gardens
- handling potatoes
- radish sprouts, alfalfa sprouts
- yogurt
- undercooked poultry, venison, lamb

Contamination of non ruminant food sources is usually attributed to contact with ruminant manure at some stage (6). Tests have shown that once introduced to lettuce and other vegetables, survival and growth under permissive temperatures is highly likely. *E coli* 0157 is unusually acid tolerant and so can grow in low pH juices (7).

An exceptionally low dose of 0157 - 2 to 2000 cells - can cause infection (5) (versus 10,000 to millions for most salmonellas (2,8)), which makes handling of contaminated materials particularly hazardous. Once introduced into a family or closed group, it can be spread by person-to-person transmission, especially by children who are not toilet trained. Young children shed 0157 in their feces for 1-2 weeks after their illness resolves; older children rarely carry 0157 without symptoms (3). Increased attention to handwashing, and particular care handling diapers (and undergarments from anyone with diarrhea) are important once infection is identified within a group (4).

Food handling: consumers' first line of defense

Precautions that apply to reducing contamination of food generally apply to 0157 (2,4,5), i.e.

- proper washing of hands before preparing food
- washing foods and preparation surfaces
- cooking meat adequately (no pink meat: internal temperatures should reach 160ºF/71ºC for ground beef, chops, and 180ºF/82 ºC for whole fowl)
- thawing meat in the refrigerator or under cold water
- not consuming unpasteurized milk
- being careful to separate raw meat from other foods in the refrigerator
- minimizing storage time of cooked food (in the refrigerator or out) before consumption.

Storage of food at room temperature and preparing food too long before consuming allow organisms such as *Salmonella* to multiply and reach critical levels, and are the most common cause of food poisoning (2). Temperatures of 8ºC and higher are conducive to growth of 0157 and may increase infection potential, however, storage at 5ºC (standard refrigerator temperature) on its own offers little protection against 0157 because of the low dose required for infection (9). There seems to be considerable potential for use of natural food additives such as garlic, cinnamon, oregano, sage and cloves to suppress 0157 in some foods (10). New strains of *Lactobacillus acidophilus* effective against 0157 are being developed (11).

E.coli 0157 on the farm

Industrialized farming practices are considered to be a factor contributing to increased levels of food borne illness associated with zoonotics (2, 12). Regardless, it is safest to assume that most of these organisms, including

0157 are everywhere including organic farms. According to Dr. Dale Hancock of Washington State University, " *E. coli* 0157 is widespread in nature, occurring naturally and sporadically in the gastrointestinal flora of humans, cattle, deer, sheep, dogs, horses, birds, and perhaps other species." (13) The specific routes by which 0157 arrives on a farm are not known although birds, deer, other wild animals and livestock brought in from other farms are suspected (14). Ruminants appear to be the primary reservoir. For example, a study in the UK found 0157 in 15.7% of cattle (dairy and beef), 2.2% of sheep, 0.4% of pigs and none in chickens (1000 of each examined) (15). The strains in pigs were non-toxigenic. Other studies have also revealed low incidence in pigs and poultry , compared to ruminants, but they have included toxigenic strains; thus while less important than cattle in the epidemiology of 0157, pigs and fowl cannot be assumed to be free of toxigenic 0157 (16). Improved detection methods indicate very high incidence of 0157 in cattle; for example, a 1999 study in the midwest US revealed 0157 in 27% of fecal samples from cattle brought to slaughterhouses during summer; 72% of the 29 lots (individual farms or feedlots) represented in samples included at least one animal positive for 0157 (17). Post-processing frequency was 2%.

Single strains (isolates with the same molecular fingerprint) often dominate a herd at one time suggesting a common source (e.g. drinking water), but can change over time indicating import of new strains (e.g. via birds) (6, 14). Over the course of a year, weaned calves and cattle may intermittently carry and not carry 0157. Immature cattle carry higher levels of 0157 than mature cattle. Shedding of 0157 in feces from an infected animal occurs over periods of weeks to months (18). Studies have usually demonstrated a strong seasonal influence on occurrence of 0157 in cattle feces (14, 18). For example, over a year long study in England, O157 was isolated from the feces from 38% of cattle presented for slaughter in the spring, but only 4.8% during the winter (15). Reported incidents of 0157 poisoning are correspondingly seasonal (3,4).

Although the prevalence of 0157 may seem alarming, food borne pathogens are something we have always lived with and different cultures have evolved a wide variety of practices to reduce the chances of food poisoning (2). If there is a single factor underlying what seems to be increasing incidents of food related bacterial diseases, it is a kind of globalization of impatience with the procurement and preparation of food (2,12). We want everything there is from everywhere, and we want it now and we want it cheap, which means cutting corners on the production side.

REDUCING OCCURRENCE AND RISKS OF *E. coli* 0157 ON THE ORGANIC FARM

Research into the life history and prevention of *E. coli* on the farm is just beginning, and for now, mostly what can be offered are guidelines that apply to zoonotic pathogens generally. What we do know about *E. coli* 0157 - notably its high toxicity for children and the elderly, its low infection dose, and its common association with healthy ruminants behoove a highly precautionary approach.

Handling and processing manure

Fresh manure, particularly during summer months, has a high probability of carrying 0157 and other pathogens. Thus special precautions should be followed in handling fresh manure, such as wearing protective clothing, avoiding hand contact with the mouth, eyes and nose, and washing after

handling livestock and manure. Activities of small children in the vicinity of livestock and manure should be carefully monitored and directed (if allowed at all: in Sweden and the UK it has been recommended that children under 5 do not visit livestock farms (19)); farm families need also to be aware that farm companion animals can transmit 0157 to humans (18). Hides are readily contaminated by fecal materials, and can be a source of 0157 in slaughterhouses (17), thus livestock should be as clean as possible before being sent to the abattoir.

Composting, a key component of organic farming, is a pathogen reduction process. Under experimental conditions, most bacterial pathogens are killed by exposure to temperatures of 55-60ºC for a few hours or less (8). Such temperatures are achieved and last for days to weeks in the thermophilic stage of composting. Canadian commercial compost standards require that under windrow composting a temperature of 55ºC or greater is maintained for at least 15 days during the composting period and that during this period, the compost is turned at least five times (20). For industrial composting systems in which the composting process is conducted indoors, is closely monitored and controlled, and for which different sets of equipment are used at earlier and later stages of processing to avoid reintroduction of pathogens, a high degree of consistency in the elimination of pathogens can be achieved.

With many or most farm composting systems, there is less control over the process and it is more difficult to ensure uniform exposure to high temperatures without overheating. This increases the importance of other factors in the destruction of pathogens. Colueke (21) cites four:

- (i) antibiosis (suppressive effects of other microbes)
- (ii) physical and chemical changes e.g. in pH
- (iii) competition for nutrients with the normal compost flora and destruction of the pathogen's original nutrient supply
- (iv) time

How well the pathogens get exposed to these agents is a function of the method of management, which he discusses in some detail for windrow, static piles and mechanically mixed compost. Regardless, he says that even when all pathogens are assumed to have been killed, prudence dictates a certain amount of caution. If pathogens do survive, their survival under field conditions becomes another factor. He says that if sewage sludge or other forms of body wastes are composted, then complete destruction of pathogens is essential before the compost product can be safely used for row crop and leafy vegetable production, that is if the vegetables are destined to be eaten raw. He goes on to say "Unless a span of at least a year is involved, such compost should be pasteurized." He emphasizes in several places the importance of time to allow lethal factors and mechanisms to exert their full effects. " Our work and that of others demonstrate that time can substitute for frequency [of turning]."

Thus the usually applied organic standard that untreated manure must be aged before application to food crops is consistent with this principle, and should be strictly adhered to. Allowing time for proper maturation (curing) of compost is also important. Two to four month curing times have been suggested for backyard composts to rid them of 0157 (22).

It is very important not to reintroduce pathogens into matured compost by mixing it with uncomposted or immature compost.

Aeration, independent of heating, appears to suppress 0157 in manure. Kudva et al. (6) found 0157 after more than one year in a non-aerated ovine manure pile, however in experimentally aerated ovine and bovine manure, it was not found after 4 months and 47 days respectively. The aerated piles were small, and the authors speculated that drying cycles were responsible for pathogen reduction; they remarked that "*E. coli* O157:H7 was never recovered from the dry top layer of any manure pile."

In the discussion section of their paper, Kudva et al. (6) attribute some of the increase in food borne pathogens to the increased density of animals on farms and the development of quick methods for disposal of wastes, notably use of slurries versus traditional methods employing bedding and composting. They remark that "Farm effluents should be contained in holding tanks with proper aeration for appropriate lengths of time (1 to 3 months or as required) before being used as fertilizers... Improperly incubated and/or stored slurry can serve as a vehicle for environmental spread and propagation of pathogens that may include *E. coli* O157:H7."

Composting and curing, aging of uncomposted manure and aeration of slurries are obviously important for use on food crops, but may be important even for forage crops in order to reduce levels of 0157 in livestock. *E. coli* 0157 survives much longer in manure products than in the live animals, and thus manure contaminated materials are suspected to be a reservoir of 0157 for reinfection of livestock (6). Contradicting this expectation, one study found that application of manure to forage crops was not associated with prevalence of *E coli* 0157, nor was feeding on pasture versus feeding on dry lots (23). Nevertheless, until there is much more conclusive evidence on this score, a highly precautionary approach seems advisable.

Feed and Water

Drinking water for livestock has been clearly demonstrated as a conduit and possibly the main conduit for transmission of 0157 from one animal to another, and it appears that water can be contaminated by oral contact alone (24). Dale Hancock at Washington State University, who has conducted extensive research into the occurrence of 0157 on farms is convinced that survival and multiplication in feed and water troughs are major factors affecting levels on the farm. He is cited (13) as offering these two "top tips":

- *E. coli* 0157 grows in wet feeds, but growth can be stopped by using mixed rations containing silage with high levels of certain acids;
- Frequent cleaning and appropriate sanitation of water troughs can potentially prevent replication and/or long term maintenance of *E. coli* 0157 in sediments.

Also, there is some evidence to suggest that use of small water reservoirs with frequent refilling is less conducive to 0157 than use of large reservoirs (24).

The significance of feeding regime for control 0157 is currently quite controversial. For example, Hancock and others dispute (25) a highly publicized study suggesting that feeding hay to cattle before slaughter could reduce incidents of 0157 in slaughterhouses. Thus for now, it appears that more reliance should be put on sanitation than on feeding regime as a primary line of defense.

Minimal use of antibiotics

In a study of a cohort of 15 heifers on each of 4 Wisconsin dairy farms differing

in management, 0157 was not observed in once weekly sampling over a 14 month study period on the two farms that used antimicrobials only occasionally and made no use of sulfonamides, while cohorts tested positive on the 2 farms where antimicrobials were used. There were other differences between the management systems, notably in the regimes for providing water, that could account for lack of 0157 on the two farms, but the authors remarked that antimicrobial use could be a risk factor for 0157 shedding in cattle, and that further research is required. Of the two farms on which 0157 was found, the highest level of antibiotic resistance in 0157 was found on the farm with highest use of antibiotics (24).

Probiotics

Probiotics are infusions of beneficial bacteria that can survive the stomach acids and become established in the intestine where they counteract, in some way, harmful bacteria, or have other beneficial effects. They are frequently used to establish desirable organisms in young animals (we are all born without intestinal bacteria), and after antibiotic treatments have eliminated desirable as well as undesirable organisms. A scientific study found one commercial product to be effective in reducing caecal colonization of chicks by both a poultry pathogenic *E.coli*, and by *E.coli* 0157 (26). Probiotics are more difficult to use this way with older ruminants because of the high levels of native bacteria, however, effective products may be available within a few years (27, 28). Commercial strains of *Lactobacillus acidophillus* specifically antagonistic to *E coli* 0157 are being developed (11).

Survival in soil

In general, survival of pathogens in soil is strongly reduced in non-sterile compared to sterilized soils, in soils that undergo periodic drying compared to constantly wet soils, and at higher temperatures compared to lower temperatures (8).

A special role for earthworms?

J.L . Spencer (29) reviewed studies including his own on effects of vermicomposting on pathogens. Worms feed on microbes, and enhance the microbial activity. Resistance of chicks to intestinal colonization by *Salmonella enteritidis* and *Salmonella typhimurium* was greatly increased if they were fed a small quantity of vermicompost produced by earthworms fed chicken feces. Spencer also notes studies indicating that earthworm activity contributes to the elimination of *Salmonella* and other pathogens in soil.

Treating liquid effluents

Liquid effluents containing fecal materials can contaminate downstream surface waters, posing hazards to the public or other farms; if recycled on the farm for irrigation, washing, flushing or use as a water source for livestock, they may contribute to maintenance of high levels of 0157 and other pathogens. Lagoon treatment systems combined with constructed wetlands are highly effective in removal of pathogens; presence of vegetation enhances removal compared to systems without vegetation, and efficiency of removal increases with species diversity of the wetland vegetation (30). There appear to have been few studies specifically on removal of 0157. Based on survival of *E. coli* 0157 and *Salmonella* inoculated into water samples from a lagoon-wetland system, McCaskey et al. (31) suggest that wastewater stored in lagoons and/or treated in the wetlands for a combined period of 20 days is safe for irrigation

and cleaning purposes.

CONCLUSION

From what we know about 0157, there is no reason to suspect that organic produce is more likely to carry 0157 than conventional produce, and there is even some basis for hypothesizing that 0157 could be less common in organic than in conventional livestock systems. Several of the core practices and principles of organic farming - notably the aging and composting of manure, the general desire to operate systems as nearly as closed as possible and to market locally, the infrequent use of antibiotics, the emphasis on probiotics and maintenance of healthy microflora in livestock (and people) and of high levels of microbial activity in soils - could be expected to reduce the levels of 0157 on organic farms. Unfortunately, none can ensure its absence, and there appear to be no data on occurrence of 0157 on organic farms. The routes by which 0157 moves into farms apply almost equally to organic farms (e.g. via birds that have been feeding on a farm with a high level of 0157). Thus there is no basis for complacency and special precautions are still very necessary.

What worked in the past may not work today. As much as it may run counter to what were once valid notions of healthy food, children and persons with weakened immune systems should not consume raw milk. Good sanitation practices for livestock, harvest containers and contact surfaces, and postharvest washing are very important. Farmers and their certifying organizations should encourage improvements in composting systems to achieve uniform exposure to high temperatures. Curing of compost for 4 months, aging of uncomposted manure for a year, and aeration or composting of slurries (32) should be encouraged; it also produces better amendments. More specific and stringent regulations than currently specified in certification codes may be appropriate, at least until we have a much better understanding of 0157, and how it is affected by organic practices. Intensive testing is required to establish that 0157 is NOT present on a farm, thus organic organizations might consider collaborative projects and seeking assistance to investigate 0157 on organic farms.

Some provisional guidelines for reducing *E. coli* 0157 on the organic farm

- Ensure that farm residents, workers and visitors are aware of the nature of the *E.coli* 0157 problem, and of personal preventative measures they should take to reduce risk. *
- Prohibit or carefully supervise activities of small children in areas where they might be exposed to fresh manure. *
- Follow good sanitation practices for livestock, harvest containers and contact surfaces, and wash vegetable produce free of soil.
- Flush water troughs with fresh water frequently and clean them regularly.
- Consider whether imported manure is highly likely to contain *E.coli* 0157 (e.g. fresh ruminant manure from a feedlot). *
- Take care to prevent cross contamination of old or composted manure with fresh manure. *
- Make improvements to the composting system to ensure thorough mixing of compost during the high temperature phase. *
- Allow compost to cure for 2-4 months (or longer) after the heating phase. *

- Aerate slurries for 1-3 months, or compost them, e.g. with straw
- Age uncomposted manure for at least one year before use. *
- Clean hides of livestock before taking them to the abattoir.
- Process liquid effluents from the farm in holding ponds/wetlands for 20 days or more.

*Asterisked items apply also to gardeners making use of manure

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