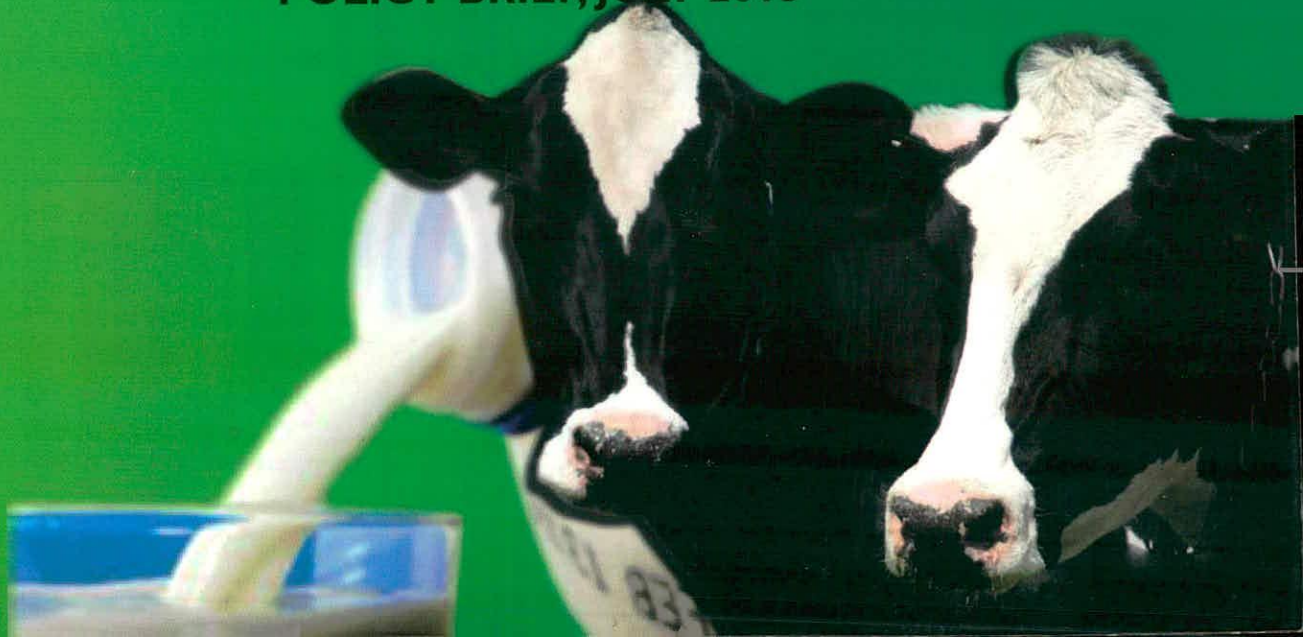
Mitigation of Milk-borne poisoning due to Enterohaemorrhagic *Escherichia coli* in Uganda

POLICY BRIEF, JULY 2015



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Background

Bovine milk is highly nutritious and contains proteins, lipids, vitamins, carbohydrates and minerals that are essential for the nutritional requirements of a growing calf. Owing to these nutritional properties, milk is also a good growth matrix for a variety of spoilage and potentially pathogenic microorganisms (Millogo *et al.*, 2005). Milk is contaminated at different points in the milk handling process and these can broadly be categorized as: farm level contamination and during transportation to markets. At the farm level, contamination can generally result from improper cleaning of milking utensil, unhygienic milkers, improper washing of the cow's udder, use of contaminated water for washing udder or milking utensils and sometimes the wagging of the tail by the milking animal (Gleeson *et al.*, 2009).

In Uganda, efforts are being made to facilitate and promote the use of milk tankers and metallic cans for milk delivery. Currently however, milk is usually transported to milk collection centres in different types of containers such as jerry cans, metallic cans and jugs. Some of these containers cannot be meticulously cleaned, thus predisposing milk to contamination. Contamination of milk with pathogens can cause milk-borne diseases in humans and animals can result in milk spoilage, all of which have grossly affected the developing dairy industries of several countries (Crump *et al.*, 2002).

The list of bacteria which can be responsible for milk-borne diseases is long and among others, includes shiga toxin-producing *Escherichia coli* (STEC) (Dhanashekar *et al.*, 2012). While the gut of humans is among the common inhabitants of the different *Escherichia coli* strains, cattle are the primary reservoirs

of STEC (WHO, 2002; Bach *et al.*, 2002; Caprioli *et al.*, 2005). Ruminants such as sheep, goats, deer are considered significant reservoirs, while other mammals (pigs, horses, rabbits, dogs, cats) and birds (chickens, turkeys) have been occasionally found infected with the pathogen (WHO, 2011; Jacob *et al.*, 2013). Although *Escherichia coli* strains are generally harmless, STEC strains have worldwide been associated with both outbreaks and sporadic cases of humans. The verocytotoxins or shiga toxins produced by these organisms, particularly *Escherichia coli* O157:H7 has been widely recognized as the major cause of a life-threatening disease manifesting as watery diarrhoea, haemorrhagic colitis (HC), and/or haemolytic uraemic syndrome (HUS) (Verweyen *et al.*, 2000; Saghaian *et al.*, 2006; Melton-Celsa *et al.*, 2012). At a population of 34.9 million people (UBOS, 2014), Uganda is estimated to suffer 3,206 annual food poisoning cases due to *Escherichia coli* (http://www.rightdiagnosis.com /e/e_coli_food_poisoning/stats-country.htm).

Products of animal origin including milk are at risk of contamination with STEC originating from animals (Hussein and Sakuma, 2005). As previously observed, there is a high potential for multinational food-borne outbreaks of illness following international trading of foods contaminated with zoonotic STEC (Kudaka *et al.*, 2005) and this can be accompanied by several trade and





public health consequences.

Challenge of controlling of *Escherichia coli*

Escherichia coli O157:H7 has been isolated from vegetables from gardens fertilized using cattle and human manure, water for livestock, manure, soil and flies, all of which represent potential sources of contamination for cattle and their environment. To date, effective methods for controlling *Escherichia coli* O157:H7 in cattle have not been appropriately identified, although dietary manipulation, vaccination and bacteriophage therapy have been reported to have potential as intervention strategies (Bach *et al.*, 2002).

Products of animal origin including milk are at risk of contamination with STEC originating from animals (Hussein and Sakuma, 2005). Whereas more than 60 of the 200 STEC *Escherichia coli* serotypes have been associated with HC or HUS in humans, the predominant serotype is EHEC O157:H7 (Beutin *et al.*, 1993). Although extensive review by Fairbrother and Nadeau (2006) indicated that EHEC O157:H7 strain had not been isolated in a number of countries, Majalija *et al.* (2008) detected zoonotic strains of *Escherichia coli* in cattle in Uganda. More recently, the EHEC O157:H7 has recently been isolated from milk at the National Livestock Resources Research Institute (NaLIRRI) in the country. Results of NaLIRRI study also revealed a high level (590,000 CFUs/100 mL) of milk contamination with *Escherichia coli* from zero-grazing farming units in central Uganda. Of greater threat is that some people have continued to take unprocessed milk, yet there is emerging resistance by *Escherichia coli* to drugs such as sulfamethoxazole-trimethoprim (Mwaka *et al.*, 2011) among patients in Uganda. While it is known that one sure way to prevent raw milk-associated foodborne illness is for consumers to refrain from drinking raw milk and from consuming dairy products manufactured using raw milk (Oliver *et al.*, 2009), only 10-20% of milk consumed in Uganda goes through the formal market chains (Jensen and Keyser, 2010). This presents a large population at risk of exposure to STEC, especially among communities where milk is consumed in raw form and those with unhygienic milk handling practices. Whereas processing may reduce the level of milk

contamination with pathogenic agents, milk marketing in most parts of Uganda is dominated by the informal sector.

Despite the fact that composting is very effective in eliminating EHEC O157:H7 from manure and should be considered as a routine practice prior to spreading the manure (Lung *et al.*, 2001), compost making is just gaining importance, especially among smallholder farmers (Mati, 2005) where occurrence of *Escherichia coli* could be hypothesized to be high. Worse is that only about 20% of the infections are responsible for 80% of the transmission to the cattle population (Matthews et al., 2006), which posses a high risk for spread of these pathogens. While some standardized, ready to use, PCR kit are becoming available, the best PCR results are usually obtained by testing extracts from primary culture (Welinder-Olsson and Kaijser, 2005). This is not always done because there are very few laboratories in the country with the biological safety level equipment recommended for culture and isolation of zoonotic pathogens such as EHEC. In addition to the low biological safety levels that characterize most of the laboratories in developing countries, the need for use of selective and differential culture media for isolation of EHEC (Gould *et al.*, 2009) makes the culture and isolation process rather expensive in developing countries in general and Uganda in particular. Detection of the specific gene sequence targets that indicate the presence of a particular EHEC strain in food and stool enrichment broths has equally remained a challenge for decades (Nataro and Kaper, 1998).

Escherichia coli O157:H7 is a quite hardy organism. It can survive for extended periods in water and soil, under frozen and refrigerated temperatures, and in dry conditions. It is quite tolerant of to acid, salt and dry conditions, especially at refrigeration temperatures. It is, however, easily destroyed by heat. The organism's low infectious dose, survival under adverse conditions, and potential for severe disease require successful prevention strategies.

Recommended options for control of Enteroheamorraghic *Escherichia coli*

Bach and colleagues (2002) suggested that effective

control of EHEC O157:H7 requires reducing the frequency and intensity of faecal shedding of this pathogen by cattle, in addition to targeting environmental sources of the organism. These strategies focus on reducing and eliminating the microorganism, be it in the environment, on the udder, on the milker's hands and the milk handling utensils. In contrast, the only effective method of eliminating EHEC from foods is to introduce a bactericidal treatment, such as heating (e.g. cooking, pasteurization) or irradiation.

Like practiced elsewhere, in order to prevent or minimize contamination of milk with this pathogen in Uganda, there is need to apply control measures at all stages of the food chain, from agricultural production on the farm to processing, manufacturing and preparation of foods in both commercial establishments and household kitchens. In order to keep microbiological contamination to a minimum, it is essential to conduct sensitisation in hygienic handling of foods among workers at farms (FAO/WHO, 2008), milk collection centres and milk processing plants/factories (FAO/WHO, 2009). The following specific guidelines are recommended in the reduction of risk of contamination of milk with *Escherichia coli* O157:H7: (1) appropriate location of milking shed/parlour, (2) irrigation of pastures should only be done using safe water, (3) proper manure management, (4) ensuring that cattle attendants clean themselves after gardening, and (5) use of sound food handling and preparation practices.

The following control practices are therefore essential:

- Irrigation of gardens requires use of potable (clean, drinkable or filtered) water.
- Pasture and vegetable gardens should be located in areas with the least potential for contamination from fresh manure.
- Gardens should be as far away as possible from animal pens (pets or livestock) and from manure or compost piles. If the garden is close to pens or manure piles, consider covering or roofing manure pile areas to prevent rainfall runoff from flowing onto the garden.
- Keep pets and livestock out of the garden, especially during the growing season.
- Check for manure contamination in runoff water from uphill neighbours.

- Divert runoff to prevent it from entering gardens or structures by building a barn or planting a grass filter strip.
- Only potable water should be used for any dairy production or value addition purposes. If this is not possible, groundwater from wells should be used; usually ground water has a lower potential for *Escherichia coli* contamination than surface water from canals, creeks or ponds. When wells are properly constructed and maintained, the deeper the well, the less chance there is for contamination of the groundwater. The source of water used should be one to which livestock or wildlife have restricted access and protected from runoffs from the neighbourhood. Also, water supply may be free of *Escherichia coli* at certain times of year and contaminated during others. Therefore, it is advisable to undertake regular sampling of water for *Escherichia coli* testing.
- Never apply uncomposted manure to gardens. Farmers should hence compost livestock manure. This should be done properly as to kill most *Escherichia coli* O157:H7; even aged manure can have *Escherichia coli* present. Microorganisms naturally occurring in soil appear to have a major influence on rates of inactivation of *Escherichia coli* O157:H7 at 15°C - 21°C (Bach et al., 2002). In order for a manure pile to be composted properly, the following requirements must be met: (1) The compost should be regularly mixed, (2) Compost temperature should be monitored with a long-stemmed thermometer (2 to 3 feet) for temperatures of 54°C - 60°C for at least two 5-day heating cycles. Compost should be mixed between cycles, (3) After composting, the compost should be allowed to cure for two to four months before applying it to garden soils. This allows the beneficial bacteria to kill disease-causing bacteria.
- Since EHEC O157:H7 is heat-sensitive, cooking should follow basic food hygiene practices such as cooking or pasteurization (heat treatment) at a temperature higher than 71°C. Raw milk should never be drunk. Like all bacteria, the survival and growth of *Escherichia coli* O157:H7 in foods are dependent on the interactions of various factors such as temperature, pH and water availability.

Hence, milk handling and preparation practices are the last line of defense for preventing infection due to *Escherichia coli* O157:H7 and other foodborne pathogens. WHO recommends following of the 5 keys to safer food including: keep clean; separation of raw from cooked food; thorough cooking; keeping food at safe (low or high) temperatures; and use of only safe, treated water and raw materials. Hands must be thoroughly washed before working with food including milk. The tools that have had direct contact with manure must be thoroughly washed and routinely disinfected. Tools used for manure handling must never be used in the milking shed. Manure-contaminated clothing must be removed, including shoes and gloves, before entering a house or before eating, drinking or processing of milk.

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References

1. Bach, S.J., McAllister, T.A., Veira, D.M., Gannon V.P.J. and Holley, R.A., 2002. Transmission and control of *Escherichia coli* O157:H7 - A review. Canadian Journal of Animal Science, 82: 475–490. http://pubs.aic.ca/doi/pdf/10.4141/A02-021
2. Beutin, L., Geier, D., Steinruck, H., Zimmermann, S. and Scheutz, F., 1993. Prevalence and some properties of verotoxin (Shiga-like toxin)-producing *Escherichia coli* in seven different species of healthy domestic animals. Journal of Clinical Microbiology, 31(9): 2483-2488.
3. Caprioli, A., Morabito, S., Brugereb, H., and Oswald, E., 2005. Enterohaemorrhagic *Escherichia coli:* emerging issues on virulence and modes of transmission. Veterinary Research, 36: 289 - 311.
4. Crump, J.A., Griffin, P.M. and Angulo, F.J., 2002. Bacterial Contamination of Animal Feed and Its Relationship to Human Foodborne Illness. Clinical Infectious Diseases, 35: 859-865
5. Fairbrother, J.M. and Nadeau, É., 2006. *Escherichia coli*: on-farm contamination of animals. Scientific and Technical Review (International Office of Epizootics), 25 (2): 555-569.
6. FAO/WHO [Food and Agriculture Organization of the United Nations/World Health Organization]. Microbiological hazards in fresh leafy vegetables and herbs: meeting report. Microbiological Risk Assessment Series No. 14, Rome, 2008
7. FAO/WHO, 2009. Codex Recommended International Code of Practice-General Principles of Food Hygiene (CAC/RCP 1-1969). In: FAO and WHO. Food Hygiene Basic Texts. Fourth Edition, 2009.
8. Gould, L.H. , Bopp, C. Strockbine, N. Atkinson, R., Baselski, V., Body, B., Carey, R., Crandall, C., Hurd, S., Kaplan, R., Neill, M., Shea, S., Somsel, P., Tobin-D'Angelo, M., Griffin, P.M., Gerner-Smidt, P., 2009. Recommendations for diagnosis of Shiga toxin-producing Escherichia coli infections by clinical laboratories. Morbidity and Mortality Weekly Report, 58, (RR-12): 1-14.

9. Jensen, M.F. and Keyser, J.C., 2010. Non-Tariff Measures on Goods Trade in The East African Community: Assessment of Regional Dairy Trade. The World Bank, Poverty Reduction and Economic Management Africa Region, Washington DC.
10. Kudaka J., Asato R., Itokazu K., Nakamura M., Taira K., Kuniyosi H., Kinjo Y., Terajima J., Watanabe H., Kobayashi J., Swaminathan B., Braden C.R. and Dunn J.R., 2005. Escherichia coli O157:H7 infections associated with ground beef from a US military installation – Okinawa, Japan, February 2004. Morbidity and Mortality Weekly Report, 54 (02): 40-42.
11. Lung, A.J., Lin, C.M., Kim, J.M., Marshall, M.R., Nordstedt, R., Thompson, N.P. and Wei, C.I., 2001. – Destruction of *Escherichia coli* O157:H7 and Salmonella enteritidis in cow manure composting. Journal of Food Protection, 64 (9): 1309-1314.
12. Majalija, S., Segal, H., Ejobi, F. and Elisha, B.G., 2008. Shiga Toxin Gene-Containing Escherichia coli from Cattle and Diarrheic Children in the Pastoral Systems of Southwestern Uganda. Journal of Clinical Microbiology, 46(1): 352–354. doi:10.1128/JCM.01995-07
13. Mati, B.M., 2005. Overview of wter and soil nutrient management under smallholder rain-fed agriculture in East Africa. Working Paper 2005. Colombo, Sri Lanka. International Water Management Institute (IWMI).
14. Matthews, L., Low, J.C., Gally, D.L., Pearce, M.C., Mellor, D.J., Heesterbeek, J.A.P., Chase-Topping, M., Naylor, S.W., Shaw, D.J., Reid, S.W.J., Gunn G.J. and Woolhouse M.E.J., 2006. Heterogeneous shedding of *Escherichia coli* O157 in cattle and its implications for control. Proceedings of the National Academy of Sciences of the United States of America, 103 (3): 547-552.
15. Mwaka, A.D., Mayanja-Kizza, H., Kigonya, E. and Kaddu-Mulindwa, D., 2011. Bacteriuria among adult non-pregnant women attending Mulago hospital assessment centre in Uganda. African Health Sciences, 11(2): 182-189.
16. Nataro, J.P. and Kaper, J.B., 1998. Diarrheagenic *Escherichia coli*. Clinical Microbiology Reviews, 11: 142–201.

17. Saghaian, S.H., Maynard, L.J., Reed, M.R., 2006. Contributed paper presented at the International Association of Agricultural Economists Conference, Gold Coast, Australia, August 12-18, 2006.
18. Verweyen, H.M., Karch, H., Brandis, M., and Zimmerhackl, L.B., 2000. Enterohemorrhagic *Escherichia coli* infections: following transmission routes. Pediatric Nephrology, 14: 73-83.
19. Welinder-Olsson, C. and Kaijser, B., 2005. Enterohemorrhagic *Escherichia coli* (EHEC). Scandinavian Journal of Infectious Diseases, 37: 405-416.
20. World Health Organization (WHO), 2002. World Health Organization. Emerging Food-borne Diseases. Fact Sheet, 2002: 124: 1-3.



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