November, 2000
Volume 63, No. 11
Pages 1465–1624
CODEN: JFPRDR 63(11)1465–1624(2000)
ISSN:0362-028X

Journal of Food Protection

"The mission of the International Association for Food Protection is to provide food safety professionals worldwide with a forum to exchange information on protecting the food supply."

Published Monthly by
International Association for
Food Protection
6200 Aurora Avenue, Suite 200W
Des Moines, Iowa 50322-2863 USA
www.foodprotection.org

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Journal of Food Protection

ISSN: 0362-028X
Official Publication

International Association for Food Protection
Formerly IAMFES
Reg. U.S. Pat. Off.

Vol. 63 **November 2000** **No. 11**

Research Notes

Review

* Asterisk indicates author for correspondence.

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Postmaster: Send address changes to *Journal of Food Protection,* IAFP, 6200 Aurora Avenue, Suite 200W, Des Moines, Iowa 50322-2863, USA.

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Journal of Food Protection, Vol. 63, No. 11, 2000, Pages 1467–1474

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The Effect of Different Grain Diets on Fecal Shedding of *Escherichia coli* O157:H7 by Steers

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MS 00-58: Received 24 February 2000/Accepted 22 May 2000

ABSTRACT

Three groups of six yearling steers (three rumen fistulated plus three nonfistulated) fed one of three different grain diets (85% cracked corn, 15% whole cottonseed and 70% barley, or 85% barley) were inoculated with 10^{10} CFU of *Escherichia coli* O157:H7 strain 3081, and the presence of the inoculated strain was followed in the rumen fluid and feces for a 10-week period. *E. coli* O157:H7 was rapidly eliminated from the rumen of the animals on all three diets but persisted in the feces of some animals up to 67 days after inoculation, suggesting that the bovine hindgut is the site of *E. coli* O157:H7 persistence. A significant difference existed in the levels of *E. coli* O157:H7 shed by the animals among diets on days 5, 7, 49, and 63 after inoculation ($P < 0.05$). No significant difference was found between the levels shed among diets on days 9 through 42 and on day 67 ($P > 0.05$). The number of animals that were culture positive for *E. coli* O157:H7 strain 3081 during the 10-week period was significantly higher for the barley fed group (72 of 114 samplings) as opposed to the corn fed group (44 of 114 samplings) ($P < 0.005$) and the cottonseed and barley fed group (57 of 114 samplings) ($P < 0.05$). The fecal pH of the animals fed the corn diet was significantly lower ($P < 0.05$) than the fecal pH of the animals fed the cottonseed and barley and barley diets, likely resulting in a less suitable environment for *E. coli* O157:H7 in the hindgut of the corn fed animals. *E. coli* O157:H7 strain 3081 was present in 3 of 30 (corn, 1 of 10; cottonseed, 1 of 10; barley, 1 of 10) animal drinking water samples, 3 of 30 (corn, 1 of 10; cottonseed, 0 of 10; barley, 2 of 10) water trough biofilm swabs, 5 of 30 (corn, 0 of 10; cottonseed, 2 of 10; barley, 3 of 10) feed samples, and 30 of 30 manure samples taken from the pens during the entire experimental period. Mouth swabs of the steers were also culture positive for *E. coli* O157:H7 strain 3081 in 30 of 180 samples (corn, 7 of 60; cottonseed, 4 of 60; barley, 19 of 60) taken during the 10-week period. Minimizing environmental dissemination of *E. coli* O157:H7 in conjunction with diet modification may reduce numbers of *E. coli* O157:H7–positive cattle.

Since 1982, when it was first identified as a human pathogen, enterohemorrhagic *Escherichia coli* O157:H7 has been implicated in numerous outbreaks of hemorrhagic colitis and life-threatening hemolytic uremic syndrome *(31, 32)*. Epidemiological investigations demonstrate that cattle, both beef and dairy, are a principal reservoir of *E. coli* O157:H7 *(17, 38)*. This association is further supported by numerous field surveys and trace-back studies that link *E. coli* O157:H7 directly and indirectly with bovine sources *(12, 17, 38)*. Although contaminated and improperly cooked ground beef has been implicated as the primary vehicle of transmission *(15, 17)*, foods such as radish sprouts *(23)*, apple cider *(4)*, unpasteurized milk *(6, 26)*, mayonnaise *(30)*, yogurt *(27)*, venison jerky *(24)*, and water *(1)* have also been linked to *E. coli* O157:H7 outbreaks.

Fecal shedding of *E. coli* O157:H7 in cattle herds is widespread and intermittent in nature *(17, 38)*. It is well known that the season and age of the animal have a significant effect on the level and duration of fecal shedding of *E. coli* O157:H7 by cattle and other ruminants. Several studies have reported peak fecal shedding of *E. coli* O157:H7 during the spring and summer months *(18, 26, 38)*. It has also been reported that weaned dairy calves and yearling beef cattle at slaughter are more likely to shed the organism in their feces than adult cattle *(14, 19, 36)*. In addition to these factors, a number of recent studies suggest that diet also influences the fecal shedding of *E. coli* O157:H7 by cattle *(8, 14, 17, 20)*.

Grain feeding is among the dietary factors that are considered to be important in respect to *E. coli* O157:H7 fecal shedding. Beef cattle are commonly fed energy-rich grain diets during the finishing periods of beef production before slaughter, and fecal shedding of *E. coli* O157:H7 at slaughter is considered to be a significant source of contamination for beef *(36)*. Rapid fermentation of grains lowers the ruminal and intestinal pH of cattle, favoring acid-resistant *E. coli* such as *E. coli* O157:H7. Although it has been reported that grain feeding as opposed to hay feeding favors acid-resistant *E. coli*, a more recent study has indicated that the acid sensitivity of *E. coli* O157:H7 is not affected by the diet of cattle *(9, 21)*. Much debate still exists concerning these findings, and it is not clear if the cattle feeding industry will advocate management changes until the issue resolves.

Information provided by numerous farm surveys sug-

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Journal of Food Protection, Vol. 63, No. 11, 2000, Pages 1529–1533
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The Synergistic Effect of Excimer and Low-Pressure Mercury Lamps on the Disinfection of Flowing Water

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MS 00-60: Received 24 February 2000/Accepted 22 May 2000

ABSTRACT

Microorganisms in flowing water were disinfected by UV radiation from two excimer (excited dimer) lamps (emitting at 172 and 222 nm) in combination with two low-pressure mercury lamps (emitting at 254 nm). Synergies were investigated among the three types of radiation in the treatment of water spiked in turn with *Escherichia coli, Listeria innocua, Shewanella putrefaciens,* and spores of *Bacillus subtilis* and *Bacillus cereus.* Synergy was demonstrated between radiations at 222 and 254 nm in the treatment of *E. coli, L. innocua,* and *S. putrefaciens,* but little or no synergy was observed in the treatment of *B. subtilis* and *B. cereus.* At maximum flow rates (60 liters/min), 5-log reductions in *E. coli* were achieved at 254 nm, although at 222 nm, less than 1-log reductions were observed. No bacterial kill was observed with 172-nm radiation alone, despite increasing exposure time by reducing flow rates to less than 3 liters/min.

The availability of safe drinking water is essential for human health and well-being. Water contamination and related food poisoning incidents cause considerable economic costs throughout the world *(2)*. The social disruption and financial consequences are great, and the illness suffered can be debilitating and sometimes life threatening, e.g., *Escherichia coli* O157, which has been linked to waterborne incidents in the UK *(12)*. The requirement for microbiologically pure water is further necessitated since some ready-to-eat foods, such as vegetables, are disinfected by aqueous treatments. The motivation for evolving new processes or new combinations of processes to disinfect and clean foods comes also from changing legislation. There are moves under way to eliminate the use of chlorine in the microbiological treatment of some foods, and processes that involve UV *(4)*, ozone *(6, 8)*, gamma irradiation *(1, 5)*, and pulsed-electric fields *(7, 13)* are receiving increasing attention.

Surface water is often contaminated with waste from animal and human activity. Underground water supplies can also be contaminated, particularly so in the case of porous soils in periods of high rainfall. The microbiological safety limit for drinking water in the UK is less than 1 coliform per 100 ml. The use of mercury UV light at 254 nm is now widespread both in the production of potable water and, to a lesser extent, in the treatment of waste water. The maximum absorption of DNA occurs at 257 nm. Higher and lower wavelengths, e.g., 222 nm, are absorbed to a lesser extent. The UV absorption causes photocleavage (severing), resulting in bacterial death *(5)* at relatively small doses (typically <10 mJ/cm^{-2}). Higher doses are required to eliminate some viruses and still higher doses (330 mJ/cm^{-2}) for *Cryptosporidium parvum (10)*.

Oppenländer et al. *(11)* suggested that bactericidal action at 254-nm radiation could be improved by supplementary radiation from excimer lamps. An excimer is an excited dimer that is a combination of two adjacent atoms or molecules that behave as a unit. Excimer lamps, developed by Kogelschatz *(9)*, make use of the excited dimer fluorescence from pairs of atoms that are excited by an electrical discharge. There are many excimer combinations, some with pairs of like atoms and others with pairs of different atoms. At the appropriate gas pressure for a chosen combination, the lamp gives an output of fluorescence centered on a specific wavelength in a narrow waveband, usually ±5 nm.

Two lamps that exhibit a high, essentially monochromatic output are the Xe_2 at 172 nm and the KrCl at 222 nm. At the lower wavelength of 172 nm, high quantum energy is produced that is sufficient to hydrolyze water into hydrogen atoms and hydroxyl radicals *(11)*. The hydroxyl radical is very short lived however (<10 μs), and the penetration depth of 172-nm radiation in water is very short (approximately 30 μm). For radiation at this wavelength, a vacuum is required between lamp and flow tube, and the envelope materials must be Spectrosil (or an equivalent) and not Vitreosil (fused silica). Photons at the higher wavelength, 222 nm, do not require a vacuum or the Spectrosil material, and they have a much deeper penetration into clear water, approximately 3 cm. In the theory of Oppenländer et al. *(11)*, radiation at 222 nm catalyses the reaction between hydroxyl radicals (which are created by the 172-nm radiation) and water itself to produce hydrogen peroxide (H_2O_2) and ozone. These products are weaker oxidizing agents than the hydroxyl radical but exist for longer periods

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