DOES WHAT WE FEED CATTLE HAVE AN EFFECT ON O157 SHEDDING?

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E. coli Webinar
Washington State University
University of Nebraska-Lincoln
Daycare  Sick friend  Swimming pools

Animal Environments

FOOD and DRINKING WATER

STEC
Direct and indirect exposure to human or animal feces

FoodNet: *E. coli* O157 incidence in 2010 was 0.9 infections /100,000 persons (3.3 / $10^5$ for children <5 yrs of age)

FoodNet, MMWR 2011 60(22) 749-755
Beef industry post-harvest interventions

- Hide treatments
- Careful evisceration
- Carcass washes
- Steam pasteurization
- Test and hold
There is a positive correlation between carcass contamination and pre-harvest carriage of O157:H7 by cattle.

“The association between fecal prevalence and carcass contamination indicates a role for control of EHEC O157 in cattle on the farm toward reducing the risk of human infection from ingestion of undercooked beef or cross-contamination of other foods. Obviously, such a control program would also reduce the risk of environmental contamination, another potential source of human infection.”


See also: Arthur et al. 2004. J Food Prot, 67(4) 658–665
There is a positive correlation between carcass contamination and pre-harvest carriage of O157:H7 by cattle.

Correlations between hide and pre-evisceration bacterial levels.

E. coli O157 prevalence for the pre-evisceration and hide samples is plotted for each sampling trip (n = 48 per trip).

Live cattle serve as an important reservoir for human *E. coli* O157:H7 exposure
Live cattle populations are an important reservoir of *E. coli* O157:H7

The cattle industry lacks on-farm interventions!

Research focus: What affects the probability for cattle to shed the organism?

What can we do about it?
Bacterial ecology: what affects the probability for cattle to shed *E. coli* O157:H7?

1) a **pen environment** when it favors bacterial survival and fecal-oral transmission, and/or

2) a **gut environment** when it favors its colonization and replication

• Smith et al. J Food Prot. 2001, 64 (12) 1899-1903.


• Smith et al. Foodborne Pathogens and Disease. 2005, 2(1):50-60
Making the gut unfavorable to STEC infection

Primary Sites of *E. coli* O157:H7 colonization:

- **rumen** *(Brown et al. 1997)*
- **colon** *(Cray & Moon, 1995)*
- **terminal rectum** *(Naylor et al. 2003)*

Enterohemorrhagic *E. coli* colonization and infection of calf rectum

Feed components
Chemicals
Competing microflora
Immune modulation

Feedlots differ in *E. coli* O157 carriage - suggesting that the cattle production system influences food safety outcomes.

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Feedots differ in *E. coli* O157 carriage - suggesting that the cattle production system influences food safety outcomes.

Everyone should be like those guys!
cattle systems may favor different agents
The effects of diet and production system on STEC O157

- Forage vs. grain feeding
- Production system
- Abrupt dietary change
- Fasting
- Grain type
- Grain processing
- Byproduct feeds
- Direct-fed microbial products
### Published Literature on Dietary Components that Affect the Carriage of Shiga-Toxin Producing *Escherichia coli* O157 (STEC O157) in Cattle

<table>
<thead>
<tr>
<th>Author</th>
<th>E. coli Population</th>
<th>Study Design</th>
<th>Sample Type</th>
<th>Comparisons</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diez-Gonzalez et al., 1998</td>
<td>Generic E. coli</td>
<td>Observed generic E. coli population</td>
<td>Fecal samples</td>
<td>No grain vs. 60% rolled corn vs. 80% rolled corn</td>
<td>Higher concentration in grain diet</td>
</tr>
<tr>
<td>Gilbert et al., 2005</td>
<td>Generic E. coli</td>
<td>Observed generic E. coli population</td>
<td>Fecal samples</td>
<td>Roughage vs. roughage + molasses vs. grain diet</td>
<td>Higher concentration in grain diet</td>
</tr>
<tr>
<td>Grauke et al., 2003</td>
<td>Generic coliforms</td>
<td>Observed generic coliforms</td>
<td>Rumen, duodenum, and fecal samples</td>
<td>90% Grain +10% triticale silage vs. 50% alfalfa + 50% timothy hay</td>
<td>Higher concentration in grain diet (rumen and fecal samples). No difference in concentration (duodenum samples).</td>
</tr>
<tr>
<td>Krause et al., 2003</td>
<td>Generic E. coli</td>
<td>Observed generic E. coli population</td>
<td>Rumen, jejunum, ileum, caecum, and fecal samples</td>
<td>100% Rhodes grass vs. 70% rolled sorghum + 30% Rhodes grass</td>
<td>Higher concentration in grain diet</td>
</tr>
<tr>
<td>Stanton and Schutz, 2000</td>
<td>Generic E. coli</td>
<td>Observed generic E. coli population</td>
<td>Fecal samples</td>
<td>85% Whole corn vs. 30% millet hay + 62% whole corn</td>
<td>Higher concentration in grain diet or duration of shedding</td>
</tr>
<tr>
<td>Grauke et al., 2003</td>
<td>STEC O157</td>
<td>Experimental Challenge Study</td>
<td>Fecal samples</td>
<td>90% Grain +10% triticale silage vs. 50% alfalfa + 50% timothy hay</td>
<td>No difference in concentration or duration of shedding</td>
</tr>
<tr>
<td>Hoyde et al., 1999</td>
<td>STEC O157</td>
<td>Experimental Challenge Study</td>
<td>Fecal samples</td>
<td>62% Barley + 19% corn vs. 90% corn vs. 100% alfalfa hay vs. 100% timothy hay</td>
<td>No difference in concentration. Increased duration of shedding in hay diet</td>
</tr>
<tr>
<td>Kudva et al., 1997</td>
<td>STEC O157</td>
<td>Experimental Challenge Study</td>
<td>Fecal samples</td>
<td>100% Grass vs. 50% corn + 50% alfalfa</td>
<td>Higher concentration and increased duration of shedding in forage diet</td>
</tr>
<tr>
<td>Tkalcic et al., 2000</td>
<td>STEC O157</td>
<td>Experimental Challenge Study</td>
<td>Fecal and rumen fluid samples</td>
<td>1.9 kg Bermuda grass + 3.8 kg concentrate mix vs. 3.8 kg bermuda grass + 1.9 kg concentrate mix</td>
<td>No difference in concentration (fecal and rumen samples)</td>
</tr>
<tr>
<td>Van Baale et al., 2004</td>
<td>STEC O157</td>
<td>Experimental Challenge Study</td>
<td>Fecal samples</td>
<td>85% Forage + 15% grain vs. 15% forage + 85% grain</td>
<td>Higher concentration and increased duration of shedding in forage diet</td>
</tr>
<tr>
<td>Diez-Gonzalez et al., 1998</td>
<td>Generic acid resistant E. coli</td>
<td>Observed generic E. coli population</td>
<td>Fecal samples</td>
<td>100% Timothy hay vs. 45% rolled corn vs. 90% rolled corn</td>
<td>Higher concentration in grain diets</td>
</tr>
<tr>
<td>Grauke et al., 2003</td>
<td>Generic acid resistant coliforms</td>
<td>Observed generic coliforms</td>
<td>Rumen, duodenum, and fecal samples</td>
<td>90% Grain +10% triticale silage vs. 50% alfalfa + 50% timothy hay</td>
<td>Greater probability to detect in grain diet (rumen and fecal samples). No difference in probability to detect (duodenum samples)</td>
</tr>
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</table>
Can what we feed cattle affect the safety of beef?

The New York Times
nytimes.com

September 11, 1998

Shift in Cow Feed May Make Beef Safer

By JANE E. BRODY

Microbiologists at Cornell University have found a way to virtually rid cattle of harmful strains of E. coli bacteria, including the bacteria that have caused scores of deaths and sickened thousands of consumers of undercooked hamburgers.

Their studies, described in today's issue of the journal Science, demonstrated that the grain-based feedlot diet usually fed to cattle before slaughter fosters growth of E. coli bacteria, some of which can cause disease. Among the dangerous strains that can survive when cattle are fed grain is E. coli O157:H7, the most deadly E. coli known.

The findings were met with enthusiasm by both the cattle industry and food safety experts.
Can what we feed cattle affect the safety of beef?

grass-fed vs. grain-fed beef
Grass vs. Grain

- Evaluate the original literature – many Internet summaries confuse generic *E. coli* with STEC O157
- Numerous studies associate grain feeding with increased fecal concentration of generic and acid-resistant *E. coli*
- In contrast, forage-based diets have been most commonly associated with increased shedding levels or increased duration of shedding of STEC O157
Most (>80%) ranch calves (on grass) have been exposed to E. coli O157 prior to weaning, and all ranch herds have E. coli O157.

After accounting for age, researchers have not seen a difference in the rates of carriage of STECs between cattle in extensive grass pastures or in confinement.

Organic vs. Natural -Beef


“Our study found similar prevalences of *E. coli* O157:H7 in the feces of organically and naturally raised beef cattle, and our prevalence estimates for cattle in these types of production systems are similar to those reported previously for conventionally raised feedlot cattle.”
Organic vs. Conventional - Dairy

"We could not find significant differences in the prevalence of STEC and O157:H7 or the risk to carry such organisms in the cattle population as a whole nor on the farm level between organic and conventional farming."

<table>
<thead>
<tr>
<th>Variable</th>
<th>OR</th>
<th>p-Value</th>
<th>LCL</th>
<th>UCL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at last lactation</td>
<td>0.68</td>
<td>0.028</td>
<td>0.49</td>
<td>0.96</td>
</tr>
<tr>
<td>Lactose in milk (%)</td>
<td>1.60</td>
<td>0.039</td>
<td>1.02</td>
<td>2.50</td>
</tr>
<tr>
<td>Urea in milk (mg/dl)</td>
<td>1.02</td>
<td>0.033</td>
<td>1.00</td>
<td>1.04</td>
</tr>
<tr>
<td>Lactation number</td>
<td>1.42</td>
<td>0.047</td>
<td>1.00</td>
<td>2.02</td>
</tr>
<tr>
<td>Unifeed trailor</td>
<td>4.84</td>
<td>0.000</td>
<td>2.94</td>
<td>7.94</td>
</tr>
<tr>
<td>Paddock available</td>
<td>1.65</td>
<td>0.019</td>
<td>1.09</td>
<td>2.51</td>
</tr>
<tr>
<td>Pasture 3–5 h vs. no pasture</td>
<td>2.16</td>
<td>0.004</td>
<td>1.28</td>
<td>3.65</td>
</tr>
<tr>
<td>Pastures &gt;5 h vs. no pasture</td>
<td>2.17</td>
<td>0.001</td>
<td>1.38</td>
<td>3.42</td>
</tr>
<tr>
<td>Organic vs. conventional farming</td>
<td>1.05</td>
<td>0.774</td>
<td>0.74</td>
<td>1.51</td>
</tr>
</tbody>
</table>

OR, odds ratio; LCL, lower confidence interval; UCL, upper confidence interval.
Abrupt feed changes and fasting

Most diet-change studies have evaluated its effect on generic E. coli.

Generally change to roughage lowers concentration of generic E. coli.

No evidence that fasting affects STEC O157 shedding.
Grain type and processing

- Greater risk for STEC O157 shedding with barley-based concentrate feeds
- Greater risk for STEC O157 shedding with steam-flaked processed corn
- Also, conflicting results...
The feeding value of WDGS in cattle finishing diets is consistently higher than corn. Studies suggest a 31 to 43% improvement in feed efficiency when WDGS replaces intermediate levels of DRC (15 to 40% of diet DM).
The probability to detect *E. coli* O157:H7 in TRM from cattle was different for cattle fed different levels of [WDGS]."

"However, the mechanisms by which diet or diet components might affect *E. coli* O157:H7 fecal shedding patterns are unclear."

Peterson et al. 2007. J Food Prot. 70(11)2568-2577
The effect of feeding distiller’s grains and vaccination on *E. coli* O157:H7 fecal shedding by feedlot cattle

- **2x2 factorial design**
  - **Vaccination**
    - 3-dose regimen compared to non-vaccinated cattle
    - d 1, 26, 53/54
  - **Diet**
    - WDGS 40% of dry-matter compared to control diet
    - Dietary treatments consisted of a 3:2 ratio of high moisture (HMC) to dry rolled corn (DRC) or 40% WDGS replacing the 3:2 HMC:DRC (DM basis)
Vaccinated cattle were 43% less likely to shed *E. coli* O157:H7.

Cattle fed WDGS 40% DM were 2.1 times more likely to shed *E. coli* O157:H7.

<table>
<thead>
<tr>
<th></th>
<th>Odds ratio</th>
<th>95% Confidence Interval</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vaccination vs not</td>
<td>0.50</td>
<td>0.36 - 0.70</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Feeding WDGS vs control</td>
<td>2.50</td>
<td>1.81 - 3.45</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Sampling Block 1 vs 2</td>
<td>0.48</td>
<td>0.30 - 0.77</td>
<td>0.0013</td>
</tr>
<tr>
<td>South Feedyard vs North</td>
<td>0.55</td>
<td>0.32 - 0.95</td>
<td>0.0318</td>
</tr>
</tbody>
</table>

Interaction between primary treatments was not significant (p=0.97)
Test period was not significant (p=0.17)
Interaction of primary treatments and test period were not significant (p>0.40)
More Questions...

Are there nutrient components that might explain a WDGS effect?

Protein
Fat
Fiber
Moisture
Sulfur

Environmental fate?

Can we feed cattle for food and environmental safety?
Probiotics / Direct-Fed Microbials

*Lactobacillus acidophilus* NP51
$10^9$ CFU/head/day
NP51-treated steers were 35% less likely to shed *E. coli* O157:H7 than were steers in untreated pens (odds ratio = 0.58, p=0.008).
Summary of LAB NP51 - Feces

<table>
<thead>
<tr>
<th>RR Feces</th>
<th>Product Efficacy</th>
<th>Lower 95% CL</th>
<th>Upper 95% CL</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.60</td>
<td>40%</td>
<td>0.49</td>
<td>0.75</td>
<td>&lt;0.01</td>
</tr>
</tbody>
</table>

P value assoc. with Q stat = 0.46; Between study variance = 0.00
Discussion

It seems reasonable that what we feed cattle might affect the bacterial population of the gut.

It is not yet clear how cattle rations affect *E. coli* O157:H7, or how to use to cattle rations as a pre-harvest intervention.

Other pre-harvest interventions can mitigate the risk of *E. coli* O157:H7 under feedlot conditions of natural exposure.
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