Reduction of fecal shedding of enterohemorrhagic 
Escherichia coli O157:H7 in lambs by feeding 
microbial feed supplement

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Abstract

Enterohemorrhagic Escherichia coli O157:H7, an emerging food-borne pathogen, has been implicated in several outbreaks in the US. Ruminants, including cattle, sheep and deer are reservoirs of E. coli O157:H7 and fecal shedding of the pathogen forms the vehicle of entry into the human food chain. We studied the efficacy of Lactobacillus acidophilus, Streptococcus faecium, a mixture of L. acidophilus and S. faecium and a mixture of L. acidophilus, S. faecium, Lactobacillus casei, Lactobacillus fermentum and Lactobacillus plantarum in reducing fecal shedding of E. coli O157:H7 by sheep experimentally infected with the pathogen prior to administration with the microbials. Following oral inoculation with 10^{10} CFU of E. coli O157:H7, 30 Suffolk ram lambs were blocked by body weight (six blocks of five lambs each) and lambs within the block randomly assigned to five groups. The lamb groups were fed daily for 7 weeks a basal diet without microbial supplement (control) or the basal diet with L. acidophilus or with S. faecium or with a mixture of L. acidophilus and S. faecium or with a mixture of L. acidophilus, S. faecium, L. casei, L. fermentum and L. plantarum. The microbial supplements contained stabilized live naturally occurring bacteria and were mixed with the diet at the rate of 6 \times 10^6 CFU per kilogram of diet. Fecal samples were collected weekly and analyzed for E. coli O157:H7 using modified tryptic soy broth with novobiocin as a pre-enrichment broth and cefixim-tellurite sorbitol MacConkey agar (CT-SMAC) as a selective media. E. coli O157:H7 was confirmed by its reaction with O157 and H7 antisera. E. coli O157:H7 was shed continuously and in varying numbers in the feces throughout the 7-week experimental period by all five groups. However, lambs administered a mixture of L. acidophilus, S. faecium, L. casei, L. fermentum and L. plantarum shed significantly lower (P \leq 0.0211) average number of E. coli O157:H7 (2.3 log_{10} CFU per gram of feces per week) than the other lamb groups over the entire experimental period. S. faecium supplemented lambs were comparable (P = 0.0884) to lambs fed a mixture of L. acidophilus and S. faecium in fecal shedding of the pathogen (3.5 versus 4.4 log_{10} CFU per gram of feces) but significantly lower (P = 0.0001) than the control lambs (5.6 log_{10} CFU per gram of feces) and those supplemented with L. acidophilus (5.5 log_{10} CFU per gram of feces). Average daily gain (ADG) and gain to feed ratio (G:F) were significantly improved (P \leq 0.0145) by the mixed culture microbials (163.0 g and 0.33 for the control, 186.4 g and 0.37 for L. acidophilus, 168.2 g and 0.36 for S. faecium, 213.6 g and 0.46 for L. acidophilus and S. faecium, and 219.1 g and 0.44, respectively for L. acidophilus, S. faecium, L. casei, L. fermentum and L. plantarum supplemented lambs. The study indicates that supplementing lambs infected with E. coli O157:H7 with S. faecium or a mixture of S. faecium, L. acidophilus, L. casei, L. fermentum and L. plantarum in the diet can reduce total number

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of E. coli O157:H7 shed in the feces and improve animal meat production performance as well. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Enterohemorrhagic E. coli O157:H7; Fecal shedding; Probiotic bacteria; Microbial feed supplement

1. Introduction

Enterohemorrhagic Escherichia coli of various serotypes have been implicated in human outbreaks of hemorrhagic colitis, adult and neonatal diarrhea, the hemolytic uremic syndrome (HUS) and thrombotic thrombocytopenic purpura (TTP) (Kamali et al., 1985; Kovacs et al., 1990; Griffin and Tauxe, 1991). Of these serotypes, E. coli O157:H7 is the most common enterohemorrhagic serotype of E. coli implicated in human food-borne illnesses of bloody diarrhea and the hemolytic uremic syndrome (Griffin, 1995). Virulent enterohemorrhagic strains of E. coli, including E. coli O157:H7, are more significant than other well-recognized food-borne pathogens for reasons including the severe consequences that affect all age groups, their low infectious dose, their unusual acid tolerance, and their association with ruminants that are used for food (Buchanan and Doyle, 1997). Enterohemorrhagic E. coli O157:H7 is capable of causing human illnesses by producing one or more related, potent toxins [verotoxin (VT), shiga-like toxin] that cause severe damage to the lining of the intestine (U.S. Food and Drug Administration, 1992). First recognized as a human pathogen in 1982, E. coli O157:H7 outbreaks in the U.S. have been reported in 1982, 1984, 1985, 1990, 1995, 1996 and 1997 (U.S. Food and Drug Administration, 1998). Enterohemorrhagic E. coli O157:H7 caused the 1993, widely publicized, hamburger-borne outbreak infections in which over 500 individuals became ill and three young children died in the Northwestern United States (Center for Disease Control, 1993). Studies have shown that apparently healthy beef and dairy cattle, and sheep harbor E. coli O157:H7 (Montenegro et al., 1990; Wells et al., 1991; Kudva et al., 1996). E. coli O157:H7 exists, at least intermittently, on a majority of cattle farms and is distributed across the U.S. and in other countries in both dairy and beef herds (Hancock and Besser, 1998). The above authors also suggested that the pattern of E. coli O157:H7 shedding by a herd might be season dependent, being higher and longer during warm weather. Kudva et al. (1996) also reported seasonal variation in E. coli O157:H7 incidence in sheep with a high of 31% in June and none in November. Studies by Rasmussen et al. (1993) indicated that E. coli O157:H7 could grow unrestricted under high pH in ruminal fluid collected from fasted animals. Similarly, Deng et al. (1998) reported that survival of E. coli O157:H7 appeared to be enhanced in foods with highest pH. To date, the source of E. coli O157:H7 contamination in meat, as in other implicated foods and water, has been linked to fecal material (Kudva et al., 1996). Other clustered cases of E. coli O157:H7 food poisoning have been linked to ingestion of unpasteurized milk, contaminated apple cider, drinking or swimming in sewage-contaminated municipal water supplies, and person to person transmission (Griffin and Tauxe, 1991; U.S. Food and Drug Administration, 1992). Therefore, knowledge about how or why ruminants shed E. coli O157:H7 will further efforts to control it.

Proper cooking is an effective method of killing E. coli O157:H7 in foods. Recent studies (Diez-Gonzalez et al., 1998) have reported that changing cattle from a concentrate-based to a hay-based diet a few days before slaughter can effectively reduce E. coli O157:H7 shedding and the subsequent contamination of meat by the pathogen. However, since changing from grain to a roughage diet results in loss of weight gain and meat production efficiency of cattle, methods that will exclude the pathogen from the animals or reduce their shedding without sacrificing animal weight gain will have greater acceptance by the livestock producer if they do not result in higher production costs. Previous studies (Zhao et al., 1998) have indicated that E. coli O157:H7 shedding can be reduced by innoculating ruminants with selected probiotic bacteria prior to infection with E. coli O157:H7. However, it is not known whether innoculating ruminant animals with probiotic bacteria after they have been infected with E. coli O157:H7 is equally effective in reducing E. coli O157:H7 shedding.
Lactobacillus acidophilus, Streptococcus faecium, Lactobacillus casei, Lactobacillus fermentum and Lactobacillus plantarum are microbial feed supplements (probiotics) commonly fed to livestock with the claim of enhancing animal performance including weight gain, feed efficiency, digestion and health. However, very little is known about their impact on the shedding of pathogens in general, and E. coli O157:H7 in particular by ruminants. The purpose of this study was to evaluate the efficacy of these probiotic bacteria at reducing E. coli O157:H7 shedding by sheep already infected with the pathogen.

2. Materials and methods

2.1. Microbial feed supplements

Four different microbial feed supplements (Chr. Hansen BioSystems, West Maple Street, Milwaukee, WI) containing stabilized concentrates of live naturally-occurring L. acidophilus, or S. faecium, or a mixture of both (L. acidophilus and S. faecium), or a mixture of L. acidophilus, S. faecium, L. casei, L. fermentum and L. plantarum were compared in the study. The microbial supplement were composed of dried fermentation product of the bacteria, dried whey, sodium sulfate and sodium silico aluminate and contained 2.0 x 10^9 CFU of microorganisms per gram of product according to counts performed in our laboratory.

2.2. Pre-experimental management of lambs

Thirty Suffolk ram lambs were selected based on closeness of body weight (45 ± 3) kg and age (12–15 months). Subsequently, all animals were ear-tagged and drenched with Ivomec (MSD-Agvet Division, Merck Rahway, NJ) for internal parasite control at the rate of 2 cc/46 kg body weight. Lambs were blocked by body weight (six blocks of five lambs each) and lambs within the block were randomly assigned to five groups. Each group consisting of six lambs was housed and fed in two 3.5 x 16 m pens (three lambs/pen) in an environmentally controlled building. Each pen had a concrete floor with individual drain, a feeding box and a water trough, and was cleaned once a day. During a 2-week pre-experimental adaptation period, all five groups of lambs were offered a basal diet of identical composition (Table 1) and fescue hay for ad libitum consumption.

2.3. Inoculation of lambs with E. coli O157:H7 and feeding of microbial supplements

At the end of the 2-week adaptation period (day 0 of experiment), initial fecal samples were collected from all five groups by retrieval from the rectum and bacterial culture for Salmonella and E. coli O157:H7 were found to be negative. The following day (day 1 of experiment), feed was withheld for 12 h and a 1 ml suspension of 10^{10} CFU of E. coli O157:H7 (American Type Culture Collection, 10801 University Boulevard, Manassas, VA) was orally administered to each lamb. Bacterial enumeration was confirmed by plating onto SMA plates supplemented with cefixime and tellurite. On day three, following inoculation with E. coli O157:H7, fecal samples were collected and bacterial culture confirmed all lambs to be positive for E. coli O157:H7 with comparable base line counts ranging from 1.7 to 1.9 log_{10} CFU per gram of feces. Starting the same day (day 3 of experiment) and for the following 7 weeks, the five groups of lambs were randomly assigned to and fed one of five different treatment diets (Table 1): basal diet without microbial supplement (Group 1, Control), or basal diet with L. acidophilus (Group 2), or basal diet with S. faecium (Group 3), or basal diet with a mixture of L. acidophilus and S. faecium (Group 4) or basal diet with a mixture of L. acidophilus, S. faecium, L. casei, L. fermentum and L. plantarum (Group 5). Each day, the microbial supplements were mixed with the diet at the rate of 0.3 g (6.0 x 10^6 CFU) per kilogram diet and offered to the lambs for ad libitum consumption. Lamb body weight was recorded at the beginning of the experiment (day 1) and fortnightly thereafter until the end of the experiment. Feed intake was recorded daily as the difference between what was offered and refused. Representative feed samples were collected daily and composited for chemical analysis at the end of the study. Feed samples were dried at 60°C in a forced draft oven, ground to pass a 1 mm screen in a Wiley Mill and analyzed for dry matter (DM), crude protein (CP) and gross energy (GE) according to AOAC (1990). The procedure of Geourcing and Van Soest (1970) was used in the partitioning of
Table 1
Composition of diets used in the study

<table>
<thead>
<tr>
<th>Ingredient (%)</th>
<th>Basal (control)</th>
<th>Basal +L. acidophilus</th>
<th>Basal +S. faecium</th>
<th>Basal +L. acidophilus +S. faecium</th>
<th>Basal +L. acidophilus +S. faecium +L. casei +L. fermentum +L. plantarum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ground fescue hay&lt;sup&gt;a&lt;/sup&gt;</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
<td>20.0</td>
</tr>
<tr>
<td>Cracked corn</td>
<td>50.1</td>
<td>50.1</td>
<td>50.1</td>
<td>50.1</td>
<td>50.1</td>
</tr>
<tr>
<td>Soybean meal, 48% CP</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
<td>18.0</td>
</tr>
<tr>
<td>Wheat bran</td>
<td>10.1</td>
<td>10.1</td>
<td>10.1</td>
<td>10.1</td>
<td>10.1</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td>Calcium carbonate</td>
<td>1.40</td>
<td>1.40</td>
<td>1.40</td>
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<td>1.40</td>
</tr>
<tr>
<td>Dicalcium phosphate</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
<td>0.09</td>
</tr>
<tr>
<td>Trace mineral salt&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
<td>0.01</td>
</tr>
<tr>
<td>L. acidophilus</td>
<td>0.0</td>
<td>0.03</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>S. faecium</td>
<td>0.0</td>
<td>0.0</td>
<td>0.03</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>L. acidophilus + S. faecium</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.03</td>
<td>0.0</td>
</tr>
<tr>
<td>L. acidophilus + S. faecium + L. casei +L. fermentum +L. plantarum</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Chemical analysis

<table>
<thead>
<tr>
<th></th>
<th>Basal (control)</th>
<th>Basal +L. acidophilus</th>
<th>Basal +S. faecium</th>
<th>Basal +L. acidophilus +S. faecium</th>
<th>Basal +L. acidophilus +S. faecium +L. casei +L. fermentum +L. plantarum</th>
</tr>
</thead>
<tbody>
<tr>
<td>CP (%)</td>
<td>14.75</td>
<td>14.75</td>
<td>14.75</td>
<td>14.75</td>
<td>14.75</td>
</tr>
<tr>
<td>ME (Mcal/kg)</td>
<td>2.41</td>
<td>2.41</td>
<td>2.41</td>
<td>2.41</td>
<td>2.41</td>
</tr>
<tr>
<td>ADF (%)</td>
<td>4.01</td>
<td>4.01</td>
<td>4.01</td>
<td>4.01</td>
<td>4.01</td>
</tr>
</tbody>
</table>

<sup>a</sup> Fescue hay ground to 3 cm length.

<sup>b</sup> Supplied > 93% NaCl, 0.35% Zn, 0.28% Mn, 0.175% Fe, 0.035% Cu, 0.007% I, and 0.007 Co.
cell-wall components into neutral-detergent fiber (NDF) and acid-detergent fiber (ADF).

2.4. Fecal sample collection, detection and enumeration of E. coli O157:H7

A sample of 10 g of feces was collected every week from each lamb by retrieval from the rectum for a period of 7 weeks while the lambs were maintained on their respective experimental diets containing the different probiotic bacteria. The fecal samples were retrieved from the rectum by hand using sterile latex gloves, which were changed between animals to avoid cross contamination. Following fecal sample collection, each animal’s ear tag was recorded and the fecal samples were placed in sterile whirl-pak bags (Fisher Scientific, Pittsburgh, PA) and immediately packed in ice and transported to the microbiology laboratory. Upon arrival in the laboratory, fecal isolation of E. coli O157:H7 was performed according to Chapman et al. (1994). Briefly, 1 g of duplicate fecal samples were aseptically added to 10 ml of 0.85% phosphate-buffered saline solution (PBS) and homogenized for 1 min. Subsequently, 1 ml of the suspension was added to 9 ml of 0.85% PBS and diluted to 10^{-9}. The suspension was thoroughly mixed and 0.1 ml plated onto Sorbitol MacConkey Agar (SMA), supplemented with cefixime and tellurite to selectively isolate E. coli O157:H7 colonies. Plates were incubated at 37°C for 18 h and visually examined for creamy white colonies containing E. coli O157:H7 (sorbitol negative) and confirmed to be E. coli O157:H7 by serological methods (Farmer and Davis, 1985).

2.5. Diarrheal score

Fecal consistency was scored at the time of sampling according to the following scales: 1 = firm pellets, 2 = normal pellets, 3 = soft pellets, 4 = soft (no pellets) but not running, 5 = soft and running. Scores of 4 and 5 were considered to be diarrhea. If diarrhea was detected, the duration was also recorded.

2.6. Statistical analysis

The data on E. coli O157:H7 shedding was analyzed by week of sample collection and over the entire experimental period (7 weeks) using the general linear model procedure of SAS (1989), while feed consumption (FC) and gain to feed ratio (G:F) ratio were analyzed over the entire period. Average daily weight gain (ADG) was arrived at by regressing body weight over time. In all cases, statistical significance was declared at P < 0.05. Duncan’s multiple range test was used to determine the existence of significant difference in the efficacy of microbial supplements in reducing fecal E. coli O157:H7 shedding and other animal performance parameters.

3. Results

3.1. Fecal shedding of E. coli O157:H7

Number of E. coli O157:H7 shed by the control and microbial supplemented group of sheep classified by week is presented in Table 2 and graphically depicted in Fig. 1. All five groups of lambs (the control group administered only E. coli O157:H7 and those administered pure or mixed cultures of microbials 1 week after inoculation with E. coli O157:H7) remained clinically healthy throughout the experimental period with no evidence of diarrhea. Fecal consistency was identical among all treatment groups. All five groups shed E. coli O157:H7 continuously and in varying numbers in the feces throughout the 7-week experimental period. Within a group, no significant variation was observed among individual lambs in baseline shedding of the pathogen and shedding thereafter during the course of the experiment. However, lambs administered a mixture of L. acidophilus, S. faecium L. casei, L. fermentum and L. plantarum shed significantly lower (P < 0.05) number of E. coli O157:H7 in the feces than the other groups over the entire experimental period. Total number of E. coli O157:H7 shed by the lamb groups supplemented with S. faecium or with a mixture of L. acidophilus and S. faecium was comparable (P > 0.05) but significantly lower (P < 0.05) than control lambs and those supplemented with L. acidophilus. As depicted in Fig. 1, E. coli O157:H7 appeared to persist in the lambs fed a mixture of L. acidophilus and S. faecium as compared to the other lamb groups. This might be attributed to incomplete colonization of the gut by the probiotic bacteria.
Table 2
Fecal *E. coli* O157:H7 shedding (log_{10} CFU/g of feces) least square means of control and microbial supplemented lambs

<table>
<thead>
<tr>
<th>Diet</th>
<th>Week post inoculation with <em>E. coli</em> O157:H7</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Basal (control)</td>
<td>5.8a (5.2–6.8)d</td>
<td>6.5a (6.0–6.6)</td>
</tr>
<tr>
<td>Basal + <em>L. acidophilus</em></td>
<td>4.2a (3.9–6.0)</td>
<td>6.5a (5.8–6.8)</td>
</tr>
<tr>
<td>Basal + <em>S. faecium</em></td>
<td>2.8b (2.5–4.5)</td>
<td>5.8a (4.6–6.4)</td>
</tr>
<tr>
<td>Basal + <em>L. acidophilus</em> + <em>S. faecium</em></td>
<td>2.1b (1.8–4.5)</td>
<td>4.6b (3.8–5.9)</td>
</tr>
<tr>
<td>Basal + <em>L. acidophilus</em> + <em>S. faecium</em> + <em>L. casei</em> + <em>L. fermentum</em> + <em>L. plantarum</em></td>
<td>2.1b (2.0–4.3)</td>
<td>4.3b (4.0–5.0)</td>
</tr>
<tr>
<td>S.E.</td>
<td>0.83</td>
<td>0.76</td>
</tr>
</tbody>
</table>

a,b,c Different letters a, b and c are statistically different (*P* < 0.05).

d Figures in parenthesis are the range of *E. coli* O157:H7 shedding.
3.2. Animal growth rate, feed consumption and feed efficiency

Feed consumption, ADG and G:F ratio results of the five groups of lambs fed the different microbial supplements in the diet are shown in Table 3. Feed consumption was comparable among the five groups. However, both ADG and G:F ratio were significantly improved ($P < 0.05$) by the mixed culture microbials containing either $L.\ acidophilus$ and $S.\ faecium$ or $L.\ acidophilus$, $S.\ faecium$, $L.\ casei$, $L.\ fermentum$ and $L.\ plantarum$.

![Graph showing E. coli O157:H7 shedding (Log10 CFU/g) in feces of lambs fed a basal diet without microbial supplement (control) or the basal diet with microbial feed supplement.](image)

**Fig. 1.** $E.\ coli$ O157:H7 shedding (Log10 CFU/g) in feces of lambs fed a basal diet without microbial supplement (control) or the basal diet with microbial feed supplement.

**Table 3**

<table>
<thead>
<tr>
<th>Diet</th>
<th>Initial weight (kg)</th>
<th>FC (gram per day)</th>
<th>ADG g</th>
<th>G:F (g:g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal (control)</td>
<td>46.4$^a$</td>
<td>500.0$^a$</td>
<td>163.0$^b$</td>
<td>0.33$^b$</td>
</tr>
<tr>
<td>Basal $+\ L.\ acidophilus$</td>
<td>46.2$^a$</td>
<td>500.0$^a$</td>
<td>186.4$^b$</td>
<td>0.37$^b$</td>
</tr>
<tr>
<td>Basal $+\ S.\ faecium$</td>
<td>45.0$^a$</td>
<td>470.0$^a$</td>
<td>168.2$^b$</td>
<td>0.36$^b$</td>
</tr>
<tr>
<td>Basal $+\ L.\ acidophilus + S.\ faecium$</td>
<td>45.5$^a$</td>
<td>461.0$^a$</td>
<td>213.6$^a$</td>
<td>0.46$^a$</td>
</tr>
<tr>
<td>Basal $+\ L.\ acidophilus + S.\ faecium + L.\ casei + L.\ fermentum + L.\ plantarum$</td>
<td>47.3$^a$</td>
<td>500.0$^a$</td>
<td>219.1$^a$</td>
<td>0.44$^a$</td>
</tr>
</tbody>
</table>

S.E. 1.8 12.0 0.07 0.14

$^a,b$ Different letters a and b are statistically different ($P < 0.05$).
4. Discussion

Sheep and cattle are widely used for meat production in US Sheep (Kudva et al., 1996), like cattle (Brown et al., 1997; Murinda et al., 1996) are reservoirs of E. coli O157:H7. To date, most of the research work with E. coli O157:H7 has been limited to cattle and very little has been done with sheep. Furthermore, research and information on the influence of microbial feed supplements, in particular Lactobacilli, Streptococci and their interactive effects on E. coli O157:H7 shedding by ruminants is not available. The rumen appears to be the main site of E. coli O157:H7 colonization and the shedding of E. coli O157:H7 in the feces may be traced back to the rumen, with the colon being only a transitional rather than a colonization site (Brown et al., 1997; Murinda et al., 1996). Therefore, changes in ruminal environment may alter E. coli O157:H7 shedding. Nutrition is among the major factors influencing the conditions in the rumen (Garber et al., 1995). It has been reported (Brown et al., 1997; Murinda et al., 1996) that E. coli O157:H7 growth is unrestricted in the rumen of fasted animals as compared to fed animals, which led researchers (Wallace et al., 1989, Rasmussen et al., 1993) to suggest a relationship between ruminal pH (resulting from diet induced volatile fatty acid production) and E. coli O157:H7 colonization of the gut. Other investigators (Diez-Gonzalez et al., 1998) suggested the opposite to be true. Deng et al. (1998) also reported that survival of E. coli O157:H7 appeared to be enhanced in foods with highest pH.

In the present study, inclusion of S. faecium alone or in combination with L. acidophilus or L. acidophilus, L. casei, L. fermentum and L. plantarum in the diet of sheep following experimental infection with E. coli O157:H7 decreased the total number of E. coli O157:H7 shed in the feces over the entire experimental period lasting for 7 weeks significantly (P < 0.05). However, the duration of shedding was not impacted. The greatest reduction in E. coli O157:H7 shedding was obtained in lambs supplemented with a mixture of L. acidophilus, S. faecium, L. casei, L. fermentum and L. plantarum. Zhao et al. (1995) reported reduced duration of E. coli O157:H7 shedding in the feces when probiotic bacteria were administered to calves prior to inoculation with E. coli O157:H7 as compared to a control group of calves receiving no probiotic bacteria. Based on their study the authors suggested that one of the factors that may influence colonization of the gastrointestinal tract by E. coli O157:H7 might be the presence or attachment of probiotic bacteria that secrete inhibitory metabolites to E. coli O157:H7 close to E. coli O157:H7 attachment sites in the gastrointestinal tract. This might explain the reduction in E. coli O157:H7 shedding observed in the present study by the microbial supplemented lambs. Although the mechanism by which the microbial supplements used in the present study reduced E. coli O157:H7 shedding is not known at present, our study indicates that a mixed culture of probiotic bacteria is more effective than a single source of probiotic bacteria in reducing E. coli O157:H7 shedding lambs.

The improvement in animal growth performance and feed efficiency of the lambs fed the mixed cultures in the present study might be a reflection of changes in overall microbial balance of the gut resulting from reduction in pathogenic microorganisms. However, the exact mechanism remains yet to be elucidated.

5. Conclusion

Supplementing lambs infected with E. coli O157:H7 with S. faecium in the diet reduces fecal E. coli O157:H7 shedding. However, more effective reduction in E. coli O157:H7 shedding can be obtained by treatment with multiple probiotic bacteria consisting of S. faecium, L. acidophilus, L. casei, L. fermentum and L. plantarum. Administration of probiotic bacteria as a microbial feed supplement not only reduces fecal shedding of the pathogen by ruminants but might also improve animal meat production performance as well. Reduction in E. coli O157:H7 shedding by ruminants decreases the chances of meat and other food products getting contaminated by the pathogen thereby decreasing the potential for E. coli O157:H7 outbreaks and associated losses.

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