

DATA ARTICLE

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Escherichia coli O157:H7 in Raw Meat in Addis Ababa, Ethiopia: Prevalence at an Abattoir and Retailers and Antimicrobial Susceptibility

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Abstract

Background: Although raw meat and its products are commonly consumed in traditional Ethiopian diets, *E. coli* O157:H7 is rarely studied compared to other countries. Thus the present study has been designed to determine the prevalence and assess the antimicrobial susceptibility of *E. coli* O157:H7 isolated from beef, sheep meat and goat meat at one abattoir and in 48 selected raw meat retail shops in Addis Ababa.

Results: Out of 384 meat samples examined, 10.2% (39/384) were positive to *E. coli* O157:H7. Among these samples examined, beef was the most frequently contaminated with *E. coli* O157:H7 with an overall prevalence of 13.3% (17/128) followed by 9.4% (12/128) sheep meat and 7.8% (10/128) goat meat. With regard to meat source, the prevalence rates of *E. coli* O157:H7 at the abattoir and the selected retail shops were 5.7% (11/192) and 14.6% (28/192), respectively. Significant differences in prevalence was observed among sample sources ($p < 0.05$). The antimicrobial susceptibility investigation of 39 *E. coli* O157:H7 isolates using 10 commercially available antimicrobial discs revealed that the isolates were susceptible to nine antimicrobials from 69.3% to 100% except streptomycin which showed susceptibility of 48.7%. An overall resistance of 33.4% and 30.9% was recorded to streptomycin and amikacin, whereas 5.1%, 5.1%, 7.7%, 12.8% and 17.9% resistance rates were recorded against nalidixic acid, tetracycline, amoxicillin-clavulanic acid, cephalothin and ciprofloxacin, respectively. Multidrug resistance was observed among amikacin, amoxicillin-clavulanic acid, cephalothin, ciprofloxacin, streptomycin and tetracycline antimicrobials drugs.

Conclusions: The isolation of *E. coli* O157:H7 in raw meat and the existence of antimicrobial resistant isolates highlight the potential threat to public health. Hence implementation of *E. coli* O157:H7 prevention and control strategies from farm production to consumption of meat and meat products are crucial.

Keywords: Abattoir; Addis Ababa; Antimicrobials; *E. coli* O157:H7; Prevalence; Retail shops; Raw meat

Background

Most *Escherichia coli* (*E. coli*) are normal commensals found in the intestinal tract of both humans and animals, while others are pathogenic to humans (CFSPH 2009; Kaper et al. 2004). Pathogenic *E. coli* distinguished from normal flora by their possession of virulence factors. The specific virulence factors can be used, together with the type of disease, to separate these organisms into pathotypes (CFSPH 2009). *E. coli* O157:H7 is one of the best known serotype to contain pathotypes that can

cause food borne infection in humans (Acha and Szyfres 2001; IFT 2003). *E. coli* O157:H7 pathotypes has been found in the intestines of healthy cattle, deer, goats, and sheep (Acha and Szyfres 2001; IFT 2003).

Verocytotoxigenic (or verotoxigenic) *E. coli* (VTEC) pathotype produces a toxin known as verocytotoxin that is lethal to cultured African green monkey kidney cells (Vero cells) (CFSPH 2009). VTEC may belong to many serotypes, but most severe human infections are caused by *E. coli* O157:H7 serotypes (Mead and Griffin 1998). Enterohemorrhagic *E. coli* O157:H7 (EHEC) is VTEC that possess additional virulence factors, giving them the ability to cause hemorrhagic colitis and hemolytic uremic syndrome (HUS) in humans. EHEC have been described as important food

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borne pathogens (Vernozy-Rozand 1999). Young children, the elderly, and those with weakened immune systems are the most vulnerable for infection (IFT 2003).

The most frequent mode of transmission for *E. coli* O157:H7 infection to human is through consumption of contaminated food and water. However, it may also spread directly from person to person and occasionally through occupational exposure (Abdalla et al. 2009).

Ruminants, particularly cattle and sheep, are the most important reservoir hosts for EHEC O157:H7 (Cornick et al. 2000). Cattle have been identified as a major reservoir of *E. coli* O157 (Chapman et al. 2001) and consumption of foods of bovine origin have been associated with some of the largest food poisoning outbreaks in which this organism was identified as the etiologic agent (Meng and Doyle 1998).

The microbiological contamination of carcasses can occur during processing and manipulation, such as skinning, evisceration, storage and distribution at slaughter houses. Fecal matter is a major source of contamination and could reach carcasses through direct deposition, as well as by indirect contact through contaminated equipment, workers, installations and air (Pal 2007). Cattle slaughtering operations, such as bleeding, dressing and evisceration expose sterile muscle to microbiological contaminants that were present on the skin, the digestive tract and in the environment (Bacon et al. 2000; Abdalla et al. 2009).

There are a few reports on the prevalence and antibiotic resistance status of *E. coli* O157: H7 from raw meat in Ethiopia and little or no studies have been carried out in Addis Ababa. Thus the current study has been designed to determine the prevalence and assess the antimicrobial susceptibility of the microorganism isolated from beef, sheep and goat's meat at one abattoir and in selected meat retail shops in Addis Ababa. The difference between the abattoir included in this study and in the study conducted by Hiko et al. (2008) with respect to the level of establishment (the abattoir included in this study supply meat for local consumption whereas the abattoir in Hiko et al. (2008). study is an export abattoir that fulfill most of international standards), the slaughtering operation and the food safety management system may enable this study to build further on the data provided by Hiko et al. (2008).

Methods

Study area

The study was carried out in Addis Ababa, the capital city of the Federal Democratic Republic of Ethiopia.

Description of food business operators included in the study

The food business operators included in this study, both the abattoir and the selected 48 retail meat shops, do

not use any formal food safety management system. The abattoir supplies meat to all of the retailers studied. All of the retail meat shops included in this study does not have any chilling/cooling facilities.

Study design

A cross-sectional study was conducted to determine the prevalence and assess the antimicrobial susceptibility of *E. coli* O157: H7 isolated from beef, sheep and goat meat at one abattoir and in 48 selected raw meat retail shops from August 2011 to April 2012 in Addis Ababa.

Study samples

The study was conducted on a total of 384 raw meat samples consisting of 64 beef, 64 sheep meat and 64 goat meat each collected from one abattoir (n = 192) and 48 randomly selected retail shops (n = 192) that means with the total of 128 beef, 128 sheep meat and 128 goat meat.

Sampling technique and sample collection procedure

Swab samples were collected aseptically using systematic random sampling technique from the carcasses of daily slaughtered animals at the abattoir and from legally registered raw meat retailer shops using simple random sampling technique.

Selected carcasses were swabbed using the method described in ISO17604 (2005) by placing sterile template (10 x 10 cm) on specific sites of a carcass. A sterile cotton tipped swab, (2X3 cm) fitted with shaft, was first soaked in an approximately 10 ml of buffered peptone water (Oxoid Ltd., Hampshire, England) rubbed first horizontally and then vertically several times on the carcasses. The abdomen (flank), thorax (lateral) and breast (lateral); which are sites with the highest rate of contamination (ISO 17604, 2005); were chosen for sampling using the same swab over all the sites. On completion of the rubbing process, the shaft was broken by pressing it against the inner wall of the test tube and disposed leaving the cotton swab in the test tube. 25 g of whole cuts of raw meat sample was collected from retail shops following aseptic techniques. The samples were put in a sterile universal bottle filled with 225 ml of buffered peptone water. Finally, the samples were transported to the Institute of Biodiversity Conservation Laboratory, Addis Ababa using ice box in cold chain for microbiological analysis. Up on arrival, the samples were stored in refrigerator at 4°C for 24 hrs until being processed for isolation.

Sample preparation

Each carcass swabs were homogenized with vortex mixer and 25 g of raw whole cuts of meat sample collected from each retail shops were taken out from the universal

bottle, chopped aseptically and the meat was placed with 225 ml of buffered peptone water; from the previous universal bottle; in a plastic bag and homogenized using a homogenizer (Stomacher 400, Seward Medical, England) at high speed for 2 minutes. The resulting suspension was used for isolation of *E. coli* O157:H7.

Isolation Procedure

200 µl of prepared sample of a meat rinse solution was streaked onto MacConkey agar (IVD, UK) plates and incubated at 37°C for 24 hrs. Following incubation, lactose-positive (pink) colonies were streaked onto Sorbitol-MacConkey Agar (IVD, UK) plates and incubated at 37°C for 24 hrs. The sorbitol negative colorless colonies were sub-cultured on Rainbow agar.

Rainbow Agar O157 (Hayward, USA) was inoculated by spreading a suspected colonies of *E. coli* on its surface. The plates were then incubated for 20 to 24 hrs, or longer, at 37°C and observed for the presence of colored colonies. The distinctive black or gray coloration of *E. coli* O157 colonies were easily viewed by laying the Petri dish against a white background. Upon sub-culturing, the isolated *E. coli* O157 colonies showed their typical black or gray coloration (BiOLOG User Guide 2008). These colonies were tested further using BiOLOG identification system to confirm their identity as *E. coli* and for any isolate identified as *E. coli* O157:H7 additional confirmation by serology may be recommended for the reasons of serious implications when this pathogen is determined in a food sample.

Identification

Pure colonies that showed typical black or gray coloration on Rainbow agar were inoculated on BUG (Biolog Universal Growth Medium) agar (Hayward, USA) with 5% sheep blood and incubated at 37°C for 24 hrs. Sub-culture was made using the same culture media to have

pure culture colonies before identification was done by OmniLog. The BUG is a recommended medium for aerobic bacteria and it was employed to isolate *E. coli*. Following this, the identification of *E. coli* O157:H7 was performed using the Omnilog plus Identification System (BiOLOG User Guide 2008).

After getting pure culture colonies, identification was carried out using BiOLOG Standard Operation Protocols (SOP). Briefly, bacterial suspension was prepared with an appropriate level of bacterial density, as recommended in the protocol of the instrument. The bacterial suspension was inoculated into the GEN III Micro Plates aseptically. The microplates were covered with lid and incubated at 37°C for 22 hrs. Then the Micro Plates were loaded into the OmniLog incubator/reader. The bacterial suspension was identified by the instrument using the inbuilt database.

Antimicrobial susceptibility pattern

The antimicrobial susceptibility test was performed following the standard agar disk diffusion method according to CLSI (2008) using commercially available antimicrobial disks (Table 1).

Table 1. Antibiotic disks used to test *E. coli* O157:H7 and their respective concentrations.

Each isolated bacterial colony from pure fresh culture was transferred into a test tube of 5 ml Tryptone Soya Broth (TSB) (Oxid, England) and incubated at 37°C for 6 hrs. The turbidity of the culture broth was adjusted using sterile saline solution or added more isolated colonies to obtain turbidity usually comparable with that of 0.5 McFarland standards (approximately 3x10⁸ CFU per ml). Mueller-Hinton agar (Bacton Dickinson and Company, Cockeysville USA) plates were prepared according to the manufacturer guidelines. A sterile cotton swab was immersed into the suspension and rotated against the side of the tube to remove the excess fluid and then

Table 1 Antibiotic disks used to test *E. coli* O157:H7 and their respective concentrations

N° Antibiotic disks	Disc code	Concentration	Diameter of zone of inhibition in millimeter (mm)			
			Resistant ≤	Intermediate	Susceptible ≥	
1	Amikacin	AK	30 µg	14	15-16	17
2	Amoxicillin-Clavulanic acid	AMC	20/10 µg	13	14-17	18
3	Ceftriaxone	CRO	30 µg	14	15-17	18
4	Cephalothin	KF	30 µg	14	15-17	18
5	Chloramphenicol	C	30 µg	12	13-17	18
6	Ciprofloxacin	CIP	5 µg	15	16-20	21
7	Nalidixic acid	NA	30 µg	13	14-18	19
8	Streptomycin	S	10 µg	11	12-14	15
9	Tetracycline	TE	30 µg	11	12-14	15
10	Sulfamethoxazole - Trimethoprim	SXT	30 µg	10	11-15	16

swabbed in three directions uniformly on the surface of Mueller-Hinton agar plates. After the plates dried, antibiotic disks were placed on the inoculated plates using sterile forceps. The antibiotic disks were gently pressed onto the agar to ensure firm contact with the agar surface, and incubated at 37°C for 24 hrs. Following this the diameter of inhibition zone formed around each disk was measured using a black surface, reflected light and transparent ruler by lying it over the plates. The results were classified as sensitive, intermediate, and resistant according to the standardized table supplied by the manufacturer (CLSI 2008). *E. coli* ATCC 25922 type strains was used as a positive control.

Data management and analysis

The coded data was entered in MS Excel (Additional file 1) and then analyzed using SPSS version 15 (2006). The overall prevalence of *E. coli* O157: H7 in raw meat was determined using standard formula. The number of positive samples was divided by the total number of samples examined multiplied by 100. In addition to these, the prevalence in each meat type as well as at the selected retail shops and the abattoir was determined in the same way by dividing positive value with corresponding total examined samples. Difference among and between proportions of the groups with certain determinant factor was determined by chi-square (χ^2) test. A p-value <0.05 was considered indicative of a statistical significant difference.

Description of raw data

The following raw data are available with the online version of this paper with sample identification and corresponding results. The data file 1 (Additional file 1) is a table listing the type of meat (beef, sheep meat, goat meat) with their corresponding result; *E. coli* O157:H7 positive meat samples were represented with 1 whereas negative samples as 0. Data file 2 (Additional file 1) contains raw data for antimicrobial susceptibility of *E. coli* O157: H7 isolated from beef, sheep meat and goat

meat at an abattoir and in 48 selected raw meat retail shops in Addis Ababa.

Results

Prevalence

The overall prevalence of *E. coli* O157:H7 in three types of raw meat samples (beef, sheep and goat's meat) was 10.2% (39/384). Out of which 13.3% (17/128) were from beef, 9.4% (12/128) from sheep meat and 7.8% (10/128) from goat meat. The test statistics among three types of raw meat samples indicated that there was no statistical significance difference in prevalence rate ($p > 0.05$) (Table 2).

Table 2. Prevalence of *E. coli* O157:H7 in abattoir and retail shops from different type of meat samples.

Among the food business operators, higher prevalence of *E. coli* O157:H7 was found in the retailer shops (14.6%) than the abattoir (6.3%) and there is significant difference in prevalence ($p < 0.05$) (Table 2). However there was no statistically significant relationship difference in prevalence of *E. coli* O157:H7 isolated from the three types of meat both in the abattoir and in the retailer shops (Table 2).

Antimicrobial susceptibility pattern

The result of antimicrobial susceptibility test of 39 *E. coli* O157:H7 isolated from raw meat samples with 10 selected antimicrobial agents is shown in Table 3. The antimicrobial sensitivity test of *E. coli* O157:H7 isolated from different raw meat types revealed a varying degree of susceptibility to antimicrobial agents tested (Table 3).

Isolates recovered from sheep meat were found to be 40% to 80% susceptible to five antimicrobial agents tested except amoxicillin-clavulanic acid, ceftriaxone, cephalothin, chloramphenicol, and sulfamethoxazole-trimethoprim antimicrobial agents, which showed 100% susceptibility (Table 3). Similarly, *E. coli* O157:H7 isolates from goat meat showed 100% susceptibility to amikacin, ceftriaxone, chloramphenicol, sulfamethoxazole-trimethoprim and tetracycline. However, the remaining isolates showed a susceptibility ranging from 58.3% to 91.7%. *E. coli* O157:H7

Table 2 Prevalence of *Escherichia coli* O157:H7 in abattoir and retail shops from different type of meat samples

Food.business operators	Samples examined	N° (%) examined	N° (%) + ve	χ^2	P-value
Abattoir	Beef	64(33.3)	3(4.7)	0.193	0.908
	Sheep meat	64(33.3)	4(6.3)		
	Goat meat	64(33.3)	4(6.3)		
Total		192(50)*	11(5.7)*		
Retail shops	Beef	64(33.3)	14(21.9)	4.348	0.114
	Sheep meat	64(33.3)	8(10.9)		
	Goat meat	64(33.3)	6(9.4)		
Total		192(50)*	28(14.6)*		

+ ve = E coli contaminated; p-value between food business operators (abattoir and retail shops)*= 0.04.

recovered from beef showed a susceptibility to antibiotic ranging from 17.6% to 100%.

Table 3. Antimicrobial susceptibility pattern of *E. coli* O157:H7 isolates (n = 39) to 10 selected antimicrobial agents.

Out of 39 *E. coli* O157:H7 isolates subjected to antimicrobial susceptibility test a total of 23.1% were susceptible to all antimicrobials used; from these 55.5% isolates were from beef, 22.2% from sheep meat and goat meat each (Table 4).

Table 4. *E. coli* O157:H7 isolates susceptible to all antimicrobials.

Of the 39 *E. coli* O157:H7 isolates, 17.9% were found to be resistant to three or more drugs tested of which 40% were recovered from beef samples (Table 5).

Table 5. Multidrug resistance (MDR) of *E. coli* O157:H7.

Discussion

Prevalence of *E. coli* O157:H7

Raw meat and its products are commonly consumed in traditional Ethiopian diets, but *E. coli* O157:H7 is rarely studied compared to other countries. In the present study, *E. coli* O157:H7 was isolated from beef, sheep meat and goat meat at both the abattoir and the selected raw meat retailer shops at Addis Ababa. The overall prevalence of *E. coli* O157:H7 in the present study (10.2%) was higher than the 4.2% reported in Modjo and Bishftu (Debre Zeit) (Hiko et al. 2008) in Ethiopia using immunomagnetic separation method which is much more sensitive than the plating method used in the present study.

The difference in the overall prevalence observed among the three types of meat samples in present study is high (13.3%) in beef, but relatively similar between sheep meat (9.4%) and goat meat (7.8%). In contrast, the

prevalence of *E. coli* O157:H7 in beef in this study was higher than the 8.8% prevalence reported by Abong (2008) in South Africa and Hajian et al. (2011) in Iran; and lower than 53% prevalence reported by Dahiru et al. (2008) in fresh beef meat in Nigeria.

In this study, the prevalence of *E. coli* O157:H7 in sheep meat (9.4%) and goat meat (7.8%) were higher than the previous study done by Hiko et al. (2008) in Ethiopia who reported a prevalence of 2.5% in sheep meat and 2% in goat meat. The presence of *E. coli* O157:H7 in sheep and goat meat might be due to contamination either from gastrointestinal content and/or skin (McEvoy et al. 2004).

With regard to meat source the higher prevalence of *E. coli* O157:H7 was found at the retailer shops (14.6%) than the abattoir (5.7%). The significant variation ($p < 0.05$) in prevalence (contamination) rate between the abattoir and the retailer shops could be due to the difference in hygienic practices, cooling and storage time used between the two. Moreover there could be risk of carcass contamination and cross and subsequent contamination, during transportation, environment, handling of meat at retailer shops.

The prevalence of *E. coli* O157:H7 was similar at the abattoir in beef, sheep meat and goat meat. There is no significant variation ($p > 0.05$) among the three type of raw meat samples. However difference in prevalence was observed among the three types of meat samples from raw meat from the retailer shops. The high prevalence was recorded in beef (21.9%) than sheep meat (10.9%) and goat meat (9.4%). This could be due to the fact that bovine has been implicated as the principal reservoir of this pathogen as compared with other food animals (Fantelli and Stephan 2001).

Table 3 Antimicrobial susceptibility pattern of *E. coli* O157:H7 isolates (n = 39) to 10 selected antimicrobial agents

Antimicrobial used	Type of raw meat and <i>E. coli</i> O157:H7 isolates											
	Beef (n = 17)			Sheep meat (n = 12)			Goat meat (n = 10)			Total (n = 39)		
	S	I	R	S	I	R	S	I	R	S	I	R
	Nº (%)	Nº (%)	Nº (%)	Nº (%)	Nº (%)	Nº (%)	Nº (%)	Nº (%)	Nº (%)	Nº (%)	Nº (%)	Nº (%)
AK	10(58.8)	0(0)	7(41.2)	10(83.6)	0(0)	2(16.6)	7(70)	0(0)	3(30)	27(69.3)	0(0)	12(30.9)
AMC	17(100)	0(0)	0(0)	9(75)	0(0)	3(25)	10(100)	0(0)	0(0)	36(92.3)	0(0)	3(7.7)
CRO	17(100)	0(0)	0(0)	12(100)	0(0)	0(0)	6(60)	4(40)	0(0)	39(100)	0(0)	0(0)
KF	15(88.2)	2(11.8)	0(0)	7(58.3)	0(0)	5(41.7)	10(100)	0(0)	0(0)	32(82.1)	2(5.1)	5(12.8)
C	17(100)	0(0)	0(0)	12(100)	0(0)	0(0)	10(100)	0(0)	0(0)	39(100)	0(0)	0(0)
CIP	13(76.5)	0(0)	4(23.5)	9(75)	0(0)	3(25)	6(60)	4(40)	0(0)	28(71.8)	4(10.3)	7(17.9)
NA	17(100)	0(0)	0(0)	10(83.6)	2(16.4)	0(0)	4(40)	4(40)	2(20)	31(79.5)	6(15.4)	2(5.1)
S	4(23.5)	7(41.1)	6(35.3)	11(91.6)	0(0)	1(8.4)	4(40)	0(0)	6(60)	19(48.7)	7(17.9)	13(33.4)
TE	17(100)	0(0)	0(0)	12(100)	0(0)	0(0)	8(80)	2(20)	2(20)	37(94.9)	0(0)	2(5.1)
SXT	17(100)	0(0)	0(0)	12(100)	0(0)	0(0)	10(100)	0(0)	0(0)	39(100)	0(0)	0(0)

See Table 2 for key abbreviations; S = Sensitive, I = Intermediate, R = Resistant.

Table 4 *E. coli* O157:H7 isolates susceptible to all antimicrobials

Type of raw meat	Nº of isolates tested	Nº (%) of isolates susceptible to all antimicrobials
Beef	17	5 (55.5)
Sheep meat	12	2 (22.2)
Goat meat	10	2 (22.2)
Total	39	9 (23.1)

Antimicrobial susceptibility pattern of *E. coli* O157:H7

The use of antibiotics in the treatment of infection with *E. coli* O157:H7 is controversial, since antimicrobial therapy may increase the risk of development of HUS (Hemolytic uremic syndromes) (Mølbak et al. 2002). Although some studies do not advise antibiotic treatment for infections caused by such bacteria (Wong et al. 2000), others suggest that disease progression may be prevented by administering antibiotic at early stage of infection (Shiomi et al. 1999). Thus, for better response, antimicrobial susceptibility test is necessary (Quinn et al. 2002). Hence, on the basis of this necessity, antimicrobial susceptibility test was conducted on the isolates recovered from raw meat.

Antimicrobial resistance of *E. coli* O157:H7 isolates from animal and human sources have been reported in Ethiopia by Hiko et al. (2008). In the present study *E. coli* O157:H7 showed resistance to seven antimicrobials which varied from 5.1% to 33.4% except to ceftriaxone, chloramphenicol, and sulfamethoxazole-trimethoprim to which 100% susceptibility was noticed. The 100% susceptibility of all the isolates to chloramphenicol, ceftriaxone and sulfamethoxazole-trimethoprim is consistent with the findings of Rangel and Marin (2009) and Rahimi and Nayeypour (2012). Most of these antimicrobials are not commonly used in Ethiopia in the treatment of animals that served as a source of meat. Moreover, the susceptibility might have contributed to the effectiveness of these antimicrobials mostly against Gram negative bacteria like those of the family of Enterobacteriaceae to which *E. coli* O157:H7 belongs.

Table 5 Multidrug resistance (MDR) of *E. coli* O157:H7

Type of drugs registered as MDR	Source of resistant isolates			Total Nº (%)
	Beef (Nº)	Sheep meat (Nº)	Goat meat (Nº)	
AK, S, TE	-	-	2	2 (28.6)
AK, CIP, S	2	-	-	2 (28.6)
AMC, CIP, S	1	-	-	1 (14.3)
AK, KF, CIP, S	1	-	-	1 (14.3)
AK, AMC, KF, S	-	1	-	1 (14.3)
Total MDR Nº (%)	4 (57.1)	1 (14.3)	2 (28.6)	7 (17.9)

See Table 2 for key abbreviations; S = Sensitive, I = Intermediate, R = Resistant.

The high resistance to streptomycin in this study is in agreement with Hiko et al. (2008) who reported antimicrobial resistance to *E. coli* O157:H7 isolates from raw meat samples to some of above mentioned antimicrobials especially to streptomycin. The significantly high level of resistance to these antimicrobials was probably an indication of their extensive usage in the veterinary sector for therapeutic and prophylactic purpose both for *E. coli* and other infections.

Antimicrobial resistance emerges from the use of antimicrobials in animals and human, and the subsequent transfer of resistance genes and bacteria among animals, humans and animal products and the environment (Scott et al. 2002). The shedding of the resistant bacteria into the environment by cattle may lead to a widespread dissemination of antibiotic resistant genes to the resident bacteria in the environment (Callaway et al. 2003; Mashood, et al. 2006). Evidence has been found which indicates that resistant strains of pathogens can be transmitted to humans through food (Oosterom 1991; Khachatourians 1998). Antibiotic resistance among food-borne pathogens may create an increased burden to human health through: it's potential to reach humans, increasing the risk of acquiring an infection in human who taking prior antibiotic treatment, limiting illness treatment options and may be by developing increased virulence (IFT 2006).

Recently, multidrug resistant (MDR) phenotypes have been spread widely among Gram negative bacteria (Ahemed et al. 2006). MDR was observed among amikacin, amoxycillin-clavulanic acid, cephalothin, ciprofloxacin, streptomycin and tetracycline antimicrobials in this study. This is in agreement with the findings by other researchers, who reported multidrug resistance among *E. coli* O157:H7 isolates (Kim et al., 1994; Schroeder et al., 2002). From the above mentioned antimicrobials streptomycin is found in all MDR *E. coli* O157:H7 isolates. This finding was supported by Hiko et al. (2008).

Increased sensitivity of antimicrobial resistant *E. coli* O157 to environmental or food processing related stresses (acid and heat) have been reported by different authors. Duffy et al. (2006) reported that MDR *E. coli* O157:H7 (resistant to 10 antibiotics) when subjected to food stresses (acid and heat) was found to act very differently to the unstressed antibiotic sensitive and antibiotic resistant VTEC strains. All VTEC strains tested were found to survive for approximately 30 days in orange juice at pH 4.4 and 25 days in yoghurt at pH 4.2. The exception was the MDR *E. coli* O157:H7 isolate which was found to have died off significantly faster ($P < 0.05$) in both media, than in the other strains tested. Thermal inactivation studies also showed the MDR strain to be significantly more heat sensitive (D55 value = 1.71 min) than all other VTEC strains examined (Clavero et al. 1998; Byrne et al. 2002; Huang and Juneja 2003).

Conclusions

One of the most significant food-borne pathogens that have gained increased attention in recent years is *E. coli* O157:H7. In this study, isolation of *E. coli* O157:H7 from raw beef, sheep meat and goat meat and the existence of resistant isolates highlight the potential threat to public health. Hence implementation of *E. coli* O157:H7 prevention and control strategies from farm production to consumption of meat and meat products are crucial.

Additional file

Additional file 1: Raw Data for Escherichia coli O157:H7 in Raw Meat in Addis and Antimicrobial Susceptibility.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

TB: conception and design, acquisition of data, analysis and interpretation of data, drafting the manuscript; GZ: conception and design, acquisition of data; drafting manuscript; GT: conception and design, acquisition of data laboratory work; AF: acquisition of data, analysis and interpretation of data, drafting the manuscript; KZ: participated in its design, analysis and interpretation of data, revising it critically for important intellectual content. All authors read and approved the final manuscript.

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References

- Abdalla MA, Siham E, Suliman YYH, Alian A (2009) Microbial Contamination of sheep carcasses at El Kadero slaughter house Khartoum State, Sudan. *J Vet Sci* 48:1–2
- Abong BO (2008) Prevalence of *Escherichia coli* O157:H7 in water and meat and meat products and vegetables sold in the Eastern Cape Province of South Africa and its impact on the diarrheic conditions of HIV/AIDS patients. Dissertation. The University of Fort Hare. Cape Town, South Africa, p 261
- Acha PN, Szyfres B (2001) Colibacillosis. In: Zoonoses and Communicable Diseases Common to Man and Animals, 3rd edn. pp 90, Washington, D.C, p 106
- Ahemed A, Li J, Shiloach Y, Robbins JB, Szu SC (2006) Safety and immunogenicity of *Escherichia coli* O157 O-specific polysaccharide conjugate vaccine in 2–5 year old children. *J Infect Dis* 193(4):515–521
- Bacon RT, Belk KE, Sofos JN, Clayton RP, Reagan JO, Smith GC (2000) Microbial populations on animal hides and beef carcasses at different stages of slaughter in plants employing multiple sequential interventions for decontamination. *J Food Prot* 63(8):1080–1086
- BiOLOG User Guide (2008) Data Collection Software Identification System User Guide. Biolog, Inc., Hayward, CA
- Byrne CM, Bolton DJ, Sheridan JJ, Blair IS, McDowell DA (2002) The effect of commercial production and product formulation stresses on the heat resistance of *Escherichia coli* O157: H7 (NCTC 12900) in beef burgers. *Int J Food Microbiol* 79:183–192
- Callaway RT, Anderson CR, Elder RO, Edrington ST, Genovese JK, Bischoff MK, Poole LT, Jung SY, Harvey BR, Nisbet JD (2003) Preslaughter Intervention Strategies to Reduce Food-Borne Pathogens in Food Animals. *J Anim Sci* 81:2
- Chapman PA, Cerda'n Malo AT, Ellin M, Ashton R, Harkin M (2001) *Escherichia coli* O157 in cattle and sheep at slaughter, on beef and lamb carcasses and in raw beef and lamb products in South Yorkshire, UK. *Int J Food Microbiol* 64 (1–2):139–150
- Clavero MRS, Beuchat LR, Doyle MP (1998) Thermal Inactivation of *Escherichia coli* O157: H7 isolated from ground beef and bovine feces, and suitability of media for enumeration. *J Food Prot* 61:285–289
- CLSI (2008) Performance Standards for Antimicrobial Disk and Dilution Susceptibility Tests for Bacterial Isolated from Animals, 3rd edn. CLSI, Wayne, PA, USA, M31-A-3, 28
- Cornick NA, Booher SL, Casey TA, Moon HW (2000) Persistent colonization of sheep by *Escherichia coli* O157:H7 and other *E. coli* pathotypes. *Appl Environ Microbiol* 66(11):4926–4934
- Dahiru M, Uraih N, Enabulele SA, Shamsudeen U (2008) Prevalence of *Escherichia coli* O157:H7 in fresh and roasted beef in Kano City. Nigeria Bayero *J Pure Appl Sci* 1:39–42
- Doyle MP, Institute of Food Technologists (IFT) (2006) Expert Panel Report Summary on Dealing with antimicrobial resistance. Institute of Food Technologists. pp 24
- Duffy G, Walsh C, Blair IS, McDowell DA (2006) Survival of antibiotic resistant and antibiotic sensitive strains of *E. coli* O157 and *E. coli* O26 in food matrices. *Int J Food Microbiol* 109:179–186
- Fantelli K, Stephan R (2001) Prevalence and characteristics of Shigatoxin-producing *Escherichia coli* and *Listeria monocytogenes* strains isolated from minces meat in Switzerland. *Int J Food Microbiol* 70:63–69
- Hajian S, Rahimi E, Mommtaz H (2011) A 3-year study of *Escherichia coli* O157:H7 in cattle, camel, sheep, goat, chicken and beef minced meat in Proceedings of the International Conference on Food Engineering and Biotechnology (IPCBE '11). IACSIT Press, Singapore
- Hiko A, Asrat D, Zewde G (2008) Occurrence of *Escherichia coli* O157:H7 in retail raw meat products in Ethiopia. *J Infect Dev Ctries* 2(5):389–393
- Huang L, Juneja VK (2003) Thermal inactivation of *Escherichia coli* O157: H7 in ground beef supplemented with sodium lactate. *J Food Prot* 66:664–667
- Institute of Food Technologists (IFT) (2003) Expert Report on Emerging Microbiological Food Safety Issues. In: Implications for Control in the 21st Century. S. Lowry/Univ. Ulster/Stone, Institute of Food Technologists, pp 1–32
- International Organization for Standardization 17604 (ISO 17604) (2005) Microbiology of Food Animal, Feeding Stuffs-Carcass Sampling for Microbiological Analysis, pp pp 1–pp 12
- Kaper JB, Nataro JP, Mobley HLT (2004) Pathogenic *Escherichia coli*. *Nat Rev Microbiol* 2:123–140
- Khachatourians G (1998) Agricultural Use of Antibiotics and the Evolution and Transfer of Antibiotic Resistant Bacteria. *CMAJ* 159:1129–1136
- Kim H, Samadpour M, Grimm L, Clausen C, Besser T, Baylor M, Kobayashi J, Neill LM, Schoenkecht F, Tarr P (1994) Characteristics of Antibiotic-Resistant *Escherichia coli* O157:H7 in Washington State, 1984–1991. *J Infect Dis* 170:1606–1609
- Mashood AR, Minga U, Machugun RK (2006) Current Epidemiologic Status of Enterohaemorrhagic *Escherichia coli* O157:H7 in Africa. *Chin Med J* 119 (3):217–222
- McEvoy JM, Sheridan JJ, McDowell DA (2004) Major pathogens associated with the processing of beef. In: Collins JD (ed) Smulders FJM. Wageningen Academic Publishers, Safety Assurance during Food Processing, pp 57–80
- McEwen SA, Fedorka-Cray PJ (2002) Antimicrobial Use and Resistance in Animals. *Clin Infect Dis* 34(Suppl3):S93–S106
- Mead PS, Griffin PM (1998) *Escherichia coli* O157:H7. *Lancet* 352(9135):1207–1212
- Meng J, Doyle MP (1998) Microbiology of shiga toxin producing *Escherichia coli* in foods. In: Kaper JB, O'Brien AD (eds) *Escherichia coli* O157:H7 and other shiga-toxin producing *E. coli* strains. American Society for Microbiology, Washington, DC, pp pp 92–pp 108
- Mølbak K, Mead PS, Griffin PM (2002) Antimicrobial therapy in patients with *Escherichia coli* O157:H7 infection. *JAMA* 288:1014–1016
- Oosterom J (1991) Epidemiological Studies and Proposed Preventive Measures in the Fight Against Human Salmonellosis. *Int J Food Microbiol* 12:41–51
- Pal M (2007) Zoonoses, 2nd edn. Satyam Publishers, Jaipur, India, pp 104–105
- Quinn P, Carter M, Markey B, Carter G (2002) Clinical Veterinary Microbiology. Enterobacteriaceae. Wolfe Pub. Spain, In, pp 209–236

- Rahimi E, Nayeypour F (2012) Antimicrobial resistance of *Escherichia coli* O157:H7/NM isolated from feces of ruminant animals in Iran. *JCAB* 6:104–108. doi:10.5897/JCAB11.082
- Rangel PM, Marin JM (2009) Antimicrobial resistance in brazilian isolates of Shiga toxin-encoding *Escherichia coli* from cows with mastitis. *ARS VETERINARIA, Jaboticabal, SP* 25:018–023
- Schroeder CM, Zhao C, DebRoy C, Torcolini J, Zhao S, White GD, Wagner DD, McDermott FP, Walker DR, Meng J (2002) Antimicrobial Resistance of *Escherichia coli* O157:H7 Isolated from Humans, Cattle, Swine, and Food. *J Appl Environ Microbiol* 68:576–581
- Shiomi M, Togawa M, Fujita K, Murata R (1999) Effect of early oral fluroquinones in hemoragic colitis do to *Escherichia coli* O157:H7. *Pediatr Int* 41(2):228–232
- SPSS (2006) Inc SPSS for windows (version 15.0). SPSS Inc., Chicago, Illinois, USA, <http://www.hist.umn.edu/~ruggles/hist5011/SPSSBriefGuide150.pdf> Accessed 7 July 2014
- The Center for Food Security and Public Health (CFSPH) (2009) Enterohemorrhagic *Escherichia coli* (EHEC) infections. http://www.cfsph.iastate.edu/Factsheets/pdfs/e_coli.pdf Accessed 12 Oct 2013
- Vernoz-Rozand C (1999) Verotoxin-producing *Escherichia coli* (VTEC) and *Escherichia coli* O157:H7 in medicine and food industry. *Ann Biol Clin* 57:507–515
- Wong CS, Jelacic S, Habeeb RL, Watkins SL, Tarr PI (2000) The risk of hemoragic uramic syndrome after antibiotic treatment of *Escherichia coli* O157:H7 infections. *N Engl J Med* 342:1930–1936

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