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Assessment of meat handling practices and occurrence of *Escherichia Coli* O157:H7 in beef meat and meat associated contact surfaces along the meat supply chain in Haramaya District, Eastern Ethiopia

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Abstract
Escherichia Coli O157:H7 is among the most newly recognized foodborne pathogens. One of the cause for *Escherichia Coli* O157:H7 pathogens was eating contaminated raw meat commonly in Ethiopia. However, poor hygienic processing and the practices of distribution are danger for contamination of beef meat leading to human infection. The current study was investigating the occurrence of *E. coli* O157:H7 in beef meat and meat associated contact surfaces along the supply chain in Haramaya District, Eastern Ethiopia. Across sectional study was used to know the occurrence of *E. coli* O157:H7 in meat and meat contact surfaces along the supply chain in Haramaya University and Haramaya town abattoirs, meat retail shops and Haramaya University students' cafeteria from April to November, 2022. The isolation and identification of process of *E. coli* O157:H7 passed through different procedures and steps with enrichment of samples with buffered peptone water (BPW) and incubated in 37 ^{o}C for overnight. The incubated samples were streaked onto MacConkey agar and incubated overnight. Colonies with pink color onto MacConkey agar were streaked on Eosin methylene blue (EMB) and then incubated overnight. Colonies with metallic green sheen on EMB were streaked on nutrient agar for farther identification of organisms using biochemical tests (Indole test, Methyl red test, Vogues Proskauer test, Triple sugar iron test and citrate utilization test) (HiMedia, Pvt., India). Colonies with positive for biochemical tests again streaked onto sorbitol MacConkey agar supplemented with 2.5mg/l cefixime and 0.5mg/l of potassium tellurite. The last identification *E. coli* O157:H7 from beef meat and meat associated contact surface was done by serological identification of organisms with latex agglutination tests. Out of 976 examined samples, 56(5.73%) were positive for *E. coli* O157:H7. Among the positive result 25 (10.08%), 18 (7.5%), 10 (4.03%) and 3 (1.25%) were samples taken from Haramaya town abattoir, Meat retail shops, Haramaya University abattoir and student cafeteria. Of these results, 7 (22.58%) from feces, 5 (16.12%) from the hide, 4 (12.23%) from hook and 4 (12.23%) from meat samples at the abattoir and 7 (29.17%) from hook, 5 (20.83%) from meat and 4 (16.7%) from cutting board at meat retail shops were significant differences among sample sources. Generally, high occurrence of *E. coli* O157:H7 in beef meat and meat associated contact surfaces was obtained in the present study in study area. Therefore, the study areas both abattoirs, meat retail shops and Haramaya University student cafeteria should give attention national and international guidelines.

Keywords: *E. coli* O157:H7, abattoir, prevalence, occurrence, meat, retail stores, feces, hide and hook

Introduction
Escherichia Coli O157:H7 is one of the most recent foodborne infections which was initially found after an epidemic involving in ground beef in 1982. *Escherichia Coli* O157:H7 has been a leading cause of foodborne disease globally. *E. coli* is a kind of facultative anaerobic, gram-negative bacteria that is found in the lower parts of colon of warm blooded animals. It is acknowledged that there are various Enterohemorrhagic *Escherichia Coli* serotypes in some of which could be more significant than *Escherichia Coli* O157:H7 in some countries (Acheson, 2000) [4]. Foodborne infections are the primary global cause of sickness and death, accounting for billions of dollars in medical expenditures globally (Havalaar *et al*., 2015) [47]. According to estimates made by the WHO, there were 31 hazards contributing to 600 million cases of food-borne illness, 420,000 fatalities and 33 million years of life with an impairment. Due to widespread inappropriate food preparation and poor sanitation practices, insufficient food safety rules, poor regulatory structure, lack safer equipments and lack

of training for workers, foodborne infection of *Escherichia Coli* O157:H7 *was* frequently happens in developing countries, notably in Africa (Hailesilassie *et al*., 2013). *Escherichia Coli* O157:H7 foodborne infections occurs after eating contaminated food, especially food derived from sick animals or beef meat that have been communized with harmful pathogens of *Escherichia Coli* O157:H7 (Nouichi and Hamdi, 2009) [73]. Most pathogens of *Escherichia Coli* O157:H7 are spreaded through feces to oral route from food animal origins, water and contact surfaces. The clinical sign of *Escherichia Coli* O157:H7 is watery diarrhea or blood with feces, abdominal pain, urinary tract infections which causes of Hemolytic uremic syndrome with different complication of bacterial diseases. Globally, about 321969086 death were occurred due to food intoxication of *Escherichia Coli* O157:H7 (Kirk *et al*., 2015) [59].

The high sources strain of *Escherichia Coli* O157:H7 is occurred when there is cross contamination at meat processing establishment during process, transportation and distribution of meat from its sources to another place for human consumption Kariuki *et al*., 2013) [57]. The main path that eventually results in ground beef contamination is contamination of carcasses during slaughter. Water, raw milk and other foods (such as lettuce, sprouts, fruit juices, vegetables and raw food) have also been linked to the spread of the disease. Person to person transmission is a significant method of infection, especially in daycare facilities. It is also known that direct contact with animals containing the pathogen can cause illness (Callaway *et al*., 2009) [23].

One of the pathogens that might infect the carcasses is *E. coli* and the feces of warm blooded animals are its main source. According to estimates, meat processing at the retail level results in a higher contamination level in minced beef than food origins. Additionally, if small amount of *E. coli* presence on the surfaces of exposed tissue of carcasses, minced meat and offal's the pathogens were crushed into pieces and grows on the surface area of the flesh. The outbreaks of illnesses linked to poor hygiene and eating unsafe food are the sources of Salmonella and *E. coli* which some pathogens of have been documented in Ethiopia (Alemseged *et al*., 2009) [42].

The most prevalence transmission mechanism of *E. coli* infection was intake of contaminated food particularly eating of undercooked and infected beef meat (Sodha *et al*., 2015) [98]. The method of transporting meat might be a significant source of contamination, particularly if basic hygiene procedures are not followed (Riley, 2014) [84] and when there is poor animal care, the amount of *E. coli* will rise at the transit of live animals (Arthur *et al*., 2017) [11].

One of the main cause of foodborne infection of *E. coli* O157:H7 was practices of eating raw meat and undercooked of beef meat (Hubaílek and Rudolf, 2010) [50].

In Ethiopia, raw meat is sold in local everywhere and stored in open air without controlling proper temperature and customers may either buy it go home or eat raw there. Culturally, the main cause of *E. coli* O157:H7 frequently occurred during eating of raw minced beef meat and undercooked flesh in some restaurants across the nation (Avery, 2004). *E. coli* O157:H7 that produce Shiga toxin (STEC) particularly O157:H7 is typically found in the stomachs of ruminant's species such as cattle, goats, sheep, deer and elk. *E. coli* O157:H7 often lives often in the digestive system these ruminants was referred as normal microflora organisms. These microflora organisms transfer to beef meat in slaughterhouse and plant processing establishment due to carelessly slaughtering animals and puncturing of gastrointestinal tracts, this may result of increasing contamination of meat and meat associated contact surfaces (Avery, 2004).

According to the website of CDC the general information of shiga toxin producing of *E. coli* O157:H7 infection may spreads from other kinds of animals, including pigs and birds, and sometimes pick up STEC from the environment may cause human illness without causing of animal sick.

According epidemiological evidence from outbreaks and sporadic cases of infection with *E. coli* O157:H7 indicates, the ground beef meat is a major sources of foodborne exposure (CDC, 2005). Taking in to account the foremost source of infection of *E. coli* O157:H7, the current information, the current information the slaughtering process of beef cattle of Haramaya University is using ground slaughter type (horizontal slaughter. When meat is managed carelessly at slaughtering process, transportation and distribute from the plant processing establishment *E. coli* O157:H7 will contaminate the meat from animate and inanimate surfaces like equipment, tables, cooking utensils, knives, and meat mincers, this is a high risk for human.

The main risk factor for human infection is carcass contamination, which occurs when a pathogen is transferred from Hide and intestinal content to carcass during the slaughtering process at processing establishment and abattoirs. According to the latest data, employees who work in slaughterhouses become sick frequently and require extra medical expenses as a result of diarrhea.

Generally, there is research gap and short information regarding the Occurrence of *E. coli* O157:H7, pathogenic *E. coli* infection and sources of *E. coli* O157:H7 from beef meat and meat associated contact surfaces and its public health significance in and around Haramaya District including from farm to fork. Therefore, this study was designed with the following objectives.

General objective

- To consider meat handling practices and occurrence of *E. coli* O157:H7 in beef meat and meat associated contact surfaces along the supply chain in two abattoirs of Haramaya District, Eastern Ethiopia.

Specific objectives

- To determine Occurrence of *E. coli* O157:H7 in beef meat and meat contact surfaces at Haramaya town abattoir, Haramaya University abattoir, meat retail shops and Haramaya University students cafeteria.
- To identify potential risk factors associated with occurrence of *E. coli* O157:H7 in meat at abattoir and along meat supply chain at Haramaya District.
- To assess meat handling practice, knowledge of slaughter personnel's and butchers at the target areas.

Materials and Methods

Study Area

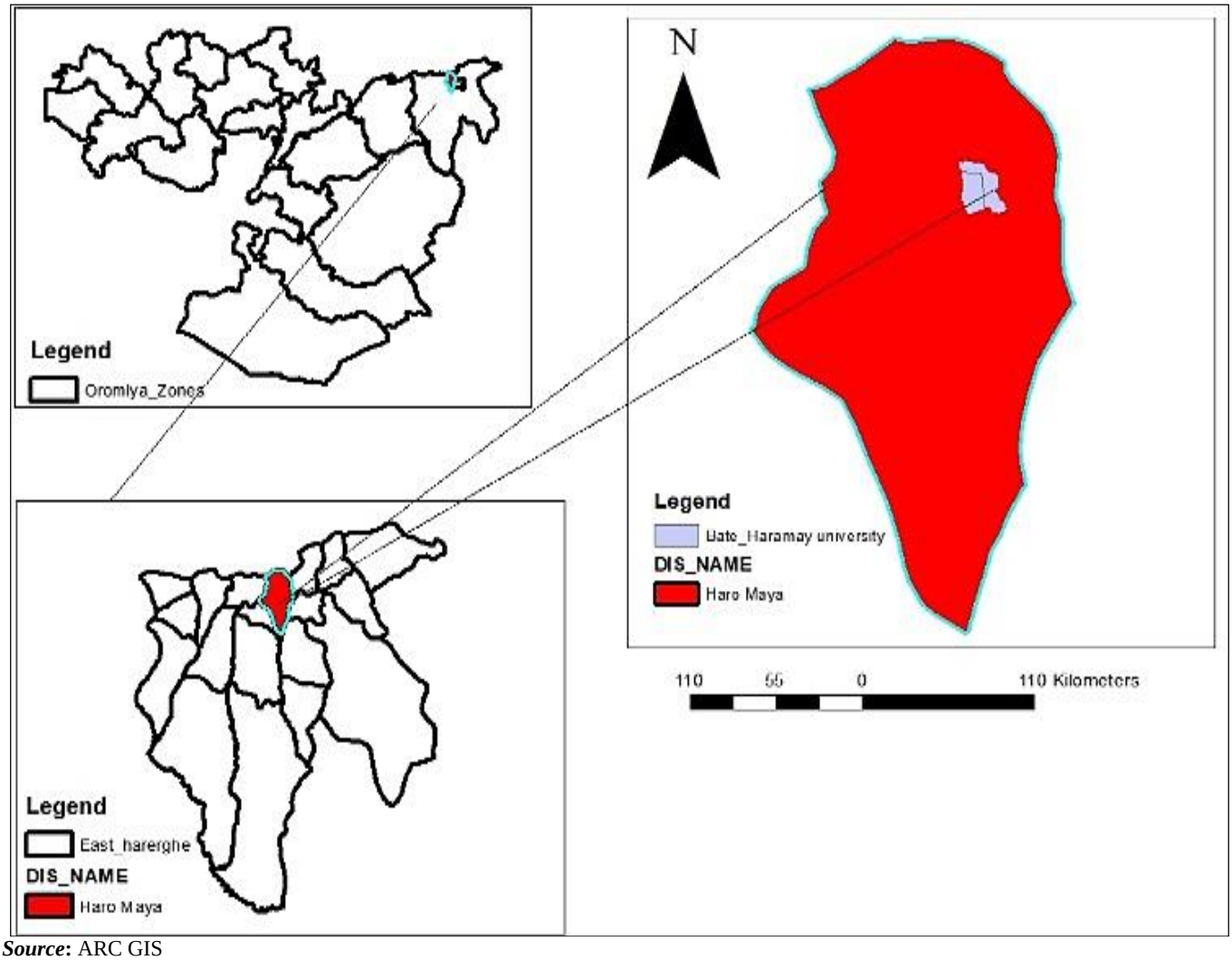
The present study was conducted on assessment of meat handling practices occurrence of *E. coli* O157:H7 in beef meat and meat associated contact surfaces along the meat supply chain in Haramaya District abattoirs, meat retail shops and Haramaya University Students' cafeteria, Eastern Ethiopia.

Addis Ababa is 505 kilometers to the east of Haramaya. The Haramaya town is located at an altitude of 1980 feet above sea level and situated at $9^{0}26'$ N latitude and 42^{0} 3' E longitude. Average of annual rainfall in the study area is 741.6mm.

The mean annual lowest and highest temperatures are 8.25 ºC and 23.4 ºC. The East Hararghe District includes Haramaya town, which is 14Km north of Harari, the regional state capital, at 9º24' N 42º0'E and 9º24`42º0` in an altitude range of 1400 to 2340 m above sea level. The temperature ranges from 9.5 to 24 ºC on average with very little variation. The district comprises two climate zone of which 66.5% is midland and 33.3% is low land. According to the Haramaya District agricultural statistics information, the district has about 63723 cattle, 13,612 sheep, 20,350 goats, 15,978 donkeys, 530 camels and 42,035 chickens.

The slaughterhouse is giving services for Haramaya University and the surrounding community. As the current information, the abattoir is not enough designed and constructed as the form of slaughter house and has no well enough infrastructures. Animal is slaughtering in horizontal and only meat is suspended on the metal stalk rail (Hook) in slaughter house.

In Haramaya University abattoir slaughtering of an animal takes place on the ground. Inedible parts like bone, intestinal by products and skin of slaughtered animals only condemned outside of slaughter house and no burying areas. The slaughter workers have no safety except bouts and overcoat. Animal were slaughtered during the morning time and the all slaughtering process have fished around 11:00 AM. The origin of animals (beef cattle) those slaughter at Haramaya University slaughter house were come from different places like Dawe, Tulu Dambi, Fadis, Dabasso and Hirna. About 10-20 beef cattle will be slaughtered daily. The meat of slaughtered cattle were weighed, and minced in the slaughter house and the minced meat were kept in meat packing plastic. The slaughter house supply the minced meat to four (4) organizations, namely, Harar campus and Hiwot Fana Referral Hospital (for health students), staff launch (for Haramaya university instructors and Haramaya university staff workers), Haramaya university student cafeteria (for Main campus students) and resource center (for training center and Guests).



***Source*:** ARC GIS

Fig 1: Study area map

Study design

A cross-sectional study was used to assessment of meat handling practices and occurrence of *E. coli* O157:H7 in beef meat and meat associated contact along the meat supply chain from April to November 2022 in Haramaya District, Eastern Ethiopia. The current laboratory based cross-sectional study was also supported with a face to face interview and observational study to assess meat handling practices in Haramaya district.

Sample size determination

The determination of sample size was based on the expected prevalence 2.06% of *Escherichia Coli* O157:H7 in cattle meat at Dire Dawa and Haramaya University (Edget *et al*., 2017) [33]. Therefore, with 95% confidence interval at 5% desired precision and using the formula recommended by (Thrusfield, 2007) [104].

$n = (1.96)^2 * P\,exp\,(1- P\,exp)/d^2$

Where
N = Required sample size.
Pexp = Expected prevalence.
D = Desired absolute precision.

Therefore, the minimum required sample was 31 beef meat samples. Hence, to increase the precision research study, the sample size were increased by 2 folds, 31x2= 62 beef cattle samples by considering by considering meat contact surfaces and other environmental samples, a total of 496 microbiological samples at two abattoirs were analyzed. At meat retail shops and Haramaya university student cafeteria about 432 environmental pooled samples and 48 meat samples were taken considering meat contact surfaces and other environmental samples, a total of 480 microbiological samples were analyzed (Table 6).

Table 6: Sample type and Sample sizes used for the study at Haramaya town and Haramaya University abattoir

Sample type		No. of samples along the chain from each abattoir				Total
		Plant A	Plant B	Plant C	Plant D	
Meat sample		31	31	24	24	110
Swab	Hide	31	31	24	24	110
	Butchers' cloth	31	31	24	24	110
	Hook	31	31	24	24	110
	Boot	31	31	-	-	62
	Hand	31	31	24	24	110
	Knife	31	31	24	24	110
	Mince machine	-	-	24	24	48
	Cooler	-	-	24	24	48
	Axe	-	-	24	24	48
	Balance weight	-	-	24	24	48
Animal Feces		31	31	-	-	62
Total		248	248	240	240	976

Therefore, 976 microbiological samples were collected and analysed from Haramaya district abattoir (Haramaya University and Haramaya town abattoir), meat retail shops, and the student cafeteria for the current study.

Sampling method procedures

At the Haramaya University abattoir and Haramaya town abattoir, cattle that were ready for slaughtering were selected using systematically random sampling method. From the Haramaya university slaughterhouse to the students' cafeteria and retailer store, as well as from the Haramaya town abattoir to butcher retail shops, samples were taken at various steps along the chain (Butcher shops).
The sample were taken from each abattoir for seven months and three weeks. Additionally, depending on the number of beef cattle slaughtered at both abattoirs, two animals were systematically selected and samples were taken on the same day from contaminated meat and meat associated contact surfaces.
In general, 976 microbiological samples were communed and analysed for the current study, and in addition to questionnaire surveys and interviews, data from the abattoir at Haramaya University abattoir workers (n = 16, workers at the abattoirs in Haramaya Town abattoir workers (n = 16), butcher shops workers (n = 16), and student cafeteria workers (n = 16) were also interviewed.

Sample collection and storage

At Haramaya university abattoir, the meat were minced in slaughterhouse before transporting to the students' cafeteria, and sample were taken at abattoir from meat at two each processing plants (Haramaya university abattoir and Haramaya town abattoir). Most types of samples were collected at processing plant establishment (Namely plant A = Haramaya town abattoir, plant B = Haramaya university abattoir, Plant C = Meat retail shops and Plant D = students cafeteria) in Haramaya university. At plant A, B, C and D samples were collected once per week for seven months and three weeks respectively.
At each processing plant establishments, two beef cattle were chosen by chance. Sample collected from the two animals Eight different sample types were collected from each animal (n = 496) at processing plant of establishments (248 samples from Haramaya town abattoir and 248 samples were collected from Haramaya University abattoir). The sample were taken from feces, meat, skin, hand, cloth, hook, boot, knife samples.
Approximately, 25g of feces sample were taken from the rectum of each animal after evisceration. This was done on the processing line and feces sample was taken directly from rectum of animal by retrieval and manually taking of feces contents using sterile gloves. Each feces sample of 25g was homogenized with 10 ml of buffered peptone water (Oxoid, CM 509). Feces samples were collected in sterile plastic bags, stored in a cooler box and transported to the laboratory within 2 hours. Raw meat samples (n =62) were collected from specific sites (neck, brisket, flank and rump) of a carcasses (ISO, 2003) in at processing plant establishments. Similarly, minced meat samples were collected from students cafeteria and meat retail shops (n = 48). Additionally, pooled swab samples or environmental swab samples were collected from knives, boot, hook, hide of animal, butchers' clothes, workers' hands, balance weight, meat mince machine, cooler, axe, table or cutting board (n=866) were collected from Haramaya town abattoir, Haramaya university abattoir, meat retail shops and student cafeteria using sterile cotton tipped swabs which presoaked in 10 ml of BPW swabbing the area 10 by 10 by using sterile cotton tipped swabs presoaked in 10 ml of BPW by swabbing the are 10 *10 cm.

The swab were put in test tube containing 10 ml of BPW (Oxoid Ltd, Hampshire, England). Cross contamination was minimized by washing the processing cutting board and using of sterile gloves changed for each animal. On each visiting day to slaughterhouse, samples were collected from environmental samples using sterile cotton tipped swab from knives, boot, hook, hide of animal, butchers' clothes, workers' hands, balance weight, meat mince machine, cooler, axe, table or cutting board before and after work before washing and after washing each meat associated contact surfaces.

The pooled environmental samples were collected and conducted two times within five months. The samples were then transported using test tube containing 10 ml of BPW (Oxoid Ltd, Hampshire, England) with using sterile equipments and safety materials.

All samples collected were transported to the microbiology of Haramaya University, College of veterinary medicine using ice box on ice packs and samples were analysed up on arrival or after incubated for 24 hours. Isolation and identification of pathogens from meat, first sample of meat was weighed, crushed in to small pieces with different sterile scalpel blade, placed in to sterile stomacher bags and diluted with 225ml of BPW, homogenized in a stomacher using 230@R for 2 minutes (ISO, 2009) [54]. Samples collected from environmental or pooled swab samples were put in a test tubes containing 9 ml of sterile BPW and incubated for 24 hrs for farther processing of laboratory procedures.

The *E. coli* O157:H7 isolation and identification was done in accourdence with (ISO 166554, 2003) standard's technique. Due to *E. coli* O157:H7 does not ferment soribitol and thus yields colorless colonies the plate culture isolation and identification have utilized using biochemical assayes, Soribiotol macconkey agar with suppliment of cefixime and potassium tellurite and serologically using latex agglutination tests kit were used.

Study methodology

Questionnaire and Observation

A check list and interview were conducted on food handlers' worker at processing plant establishment to determine hygiene status of premises and safety practices of meat handlers. In the present study, beef meat samples and meat associated contact surfaces of environmental pooled samples were collected from abattoirs, meat retail shops and students cafeteria.

Semi- structured questionnaires were developed and asked the slaughter workers to assess meat handling practices, understanding and knowledge of meat safety, personnel practices, hygiene and educational background of workers at a study area (Annex: 2 and Annex: 3).

Laboratory analysis

Isolation and identification of E. coli

Meat samples collected from abattoir and retailer shops were taken out of plastic bags using sterile forceps. Each meat samples were chopped and mixed. 25g of was transferred to sterile stomacher bag (Seward, England), containing 225ml of peptone water and homogenized using homogenizer (Stomacher 400, Seward medical, England) at 260 RPM for 2 hours.

The result of homogenized samples were incubated at 37 ^{o}C for 24 hrs. Pre-enriched samples were cultured onto MacConkey agar and incubated at 37 ^{o}C for 24hrs. One suspected colonies of *E. coli* (pinkish color appearance) were subculture onto Eosin Methylene Blue and incubated 37 ^{o}C for 24hrs. Colonies with green metallic sheen again subcultured onto nutrient agar for farther biochemical tests and incubated at 37 ^{o}C for 24hrs. Then biochemical tests were done accordingly, colonies with methylene red (positive), Vogues Proskauer test (negative), Cimon citrate test negative and triple sugar iron negative were considered as *E. coli* again subcultured onto sorbitol MacConkey agar supplement with cefixime and potassium tellurite and colonies were non fermenting sorbitol are shown colorless color were considered as *E. coli* O157:H7 and subcultured on nutrient agar for serological test using latex agglutination kit tests for confirmation.

Tests and observation for agglutination

All non-sorbitol fermenting colonies from nutrient agar were serologically confirmed using latex agglutination assay (Abraxis LLC, USA) containing latex particles with antibodies specific for *E. coli* O157:H7 antigens. Identification was take place following the manufacturer's instruction. Using one colonies of *E. coli* O157:H7 to one drops of colonies putting on test card and mixed with antibody specific.

A suspected colonies from the nutrient agar plate was picked using sing sterile bead stick and emulsified thoroughly in the drops hole in one of the circles. One free drops of the *E. coli* O157:H7 latex antibodies bead reagents was dispensed on to each circle and the test card rotated using a complete circular motion up to one minute until agglutination was evident. Agglutination of the test latex within one minute was considered and record as a positive result of *E. coli* serogroup of O157:H7. Those absence of agglutination within one minute were indicates Negative result see.

Data Management and Analysis

The result obtained from laboratory and questionnaire and interview were entered into Microsoft excel. Data from Microsoft excel was edited, coded and analysed using statistical methods in the stata version 15 software program (stata version 15.00). The descriptive statistics was used to calculate prevalence of *E. coli* O157: H7. Sources and associated risk factors for isolated *E. coli* O157:H7 was analysed using pearcen chi square association. The prevalence of *E. coli* O157:H7 was expressed by dividing the number of positive for *E. coli* O157:H7 to total numbers of samples analysed. The association of result obtained from questionnaire survey and interviews were reported using descriptive statistics. The result obtained were summarized and reported by Graph and Tables.

Result

The overall prevalence of *E. coli* O157:H7 in beef meat and meat associated contact surfaces

Of 976 examined samples at different study sites, 56(5.73%) were positive for *Escherichia Coli* O157:H7 from beef meat and meat associated contact surfaces. Out of the result obtained 25(10.08%) positive samples were collected from Haramaya town abattoir, 18(7.5%) positive for *E. coli* O157:H7 were collected from meat retail shops, 10(4.03%)

of positive for *E. coli* O157:H7 were collected from Haramaya University abattoir and 3(1.25%) of positive for *E. coli* O157:H7 were result obtained of sample collected from students cafeteria, as shown in the following Table 2.

Table 2: Occurrence of *E. coli* O157:H7 isolated from different plant processing establishment

Processing Establishment	Examined Sample	Positive No. (%)	X^2	P-value
Plant A	248	25 (10.08)	24.84	0.02
Plant B	248	10 (4.03)		
Plant C	240	18 (7.5)		
Plant D	240	3 (1.25)		
Total	976	56 (5.73)		

Out of 976 samples examined, the overall occurrence of *E. coli* O157:H7 was 56 (5.73%) in beef meat and meat associated contact surfaces along supply chain as shown on above Table 7 and in the below Figure 2. The current result obtained at both plant processing establishment were 25(10.08%) and 10 (4.03%) of Plant A and B respectively positive for *E. coli* O157:H7. Among 480 samples examined from both plant processing establishment of plant C and D 8(7.5%) and 3(1.25%) were positive for *E. coli* O157:H7 respectively.

Among four study sites of plant processing establishment, the highest result obtained was from Haramaya town abattoir, followed by a meat retailer shop, Haramaya University abattoir and the least result obtained was from the student cafeteria.

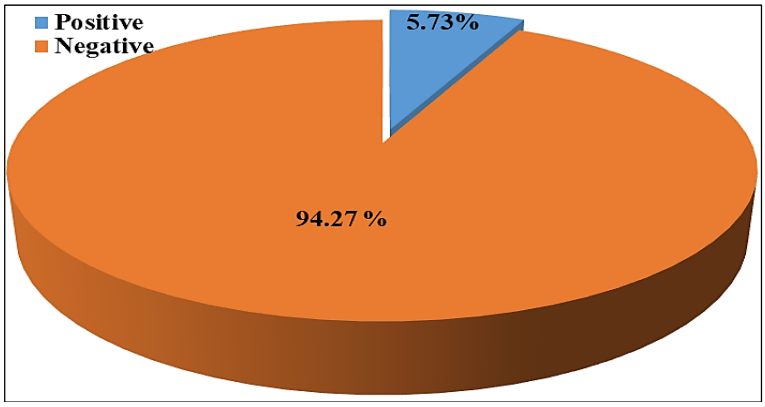


Fig 2: The total overall occurrence of *Escherichia Coli* O157:H7 at four plant processing establishment

The frequency of the occurrence of *Escherichia Coli* O157:H7 in beef meat and meat associated contact surfaces at abattoirs

At plant processing establishment of plant A and B, the obtained result of 7 (22.58%) from feces, 5 (16.12%) from skin swab, 4(12.9%) from meat, 4(12.9%) from hook swab, 2 (6.45%) from hand swab, 1 (3.23%) of boot swab, 1 (3.23%) of cloth swab and 1(3.23%) of knife swab samples were positive for *Escherichia Coli* O157:H7 at Haramaya town abattoir.

At Haramaya University abattoir, 3 (9.67%) from knife swab, 3 (9.67%) from hand swab, 2 (6.45%) from cloth swab, 1 (3.23%) from feces, 1 (3.23%) from boot swab were positive for *Escherichia Coli* O157:H7.

Table 3: The frequency of the occurrence of *Escherichia Coli* O157:H7 in beef meat and meat associated contact surfaces at abattoirs

Associated Risk Factor	Plant A		Plant B		$\chi 2$	P-value
	No. Examined	Positive No. (%)	No. Examined	Positive No. (%)		
Hide swab	31	5 (16.12)	31	0(0)	5.05	0.02
Meat sample	31	4 (12.9)	31	0(0)	4.03	0.04
Hand swab	31	2 (6.45)	31	3 (9.67)	0.20	0.65
boot swab	31	1 (3.23)	31	1 (3.23)	0.00	1.00
Cloth swab	31	1 (3.23)	31	2 (6.45)	0.33	0.56
Hook swab	31	4 (12.9)	31	0(0)	4.03	0.04
Fecal sample	31	7 (22.58)	31	1 (3.23)	4.57	0.02
Knife swab	31	1 (3.23)	31	3 (9.67)	1.01	0.31
Total	248	25 (10.08)	248	10 (4.03)		
Overall occurrence of *E. coli* O157:H7 in abattoirs			496	35 (7.06)		

The frequency of the occurrence of *Escherichia Coli* O157:H7 in beef meat and meat associated contact surfaces at meat retail shops and student cafeteria

Among the results obtained, 7 (29.17%) were from Hook swab sample, followed by 5 (20.83%) from meat swab sample, 4 (16.7%) from table or cutting board swab sample, 1 (4.17%) from knife swab sample, and 1 (4.17%) from balance weight swab sample were positive for *Escherichia Coli* O157:H7 at a meat retailer shop, and 2 (8.33%) of balance weight swab samples and 1 (4.17%) of Hook swab sample at student cafeteria were positive for *Escherichia Coli* O157:H7 as shown in the following Table 4.

Table 4: Isolation frequency of occurrence of *Escherichia Coli* O157:H7 and its associated risk factors at meat retail shops and student cafeteria

Associated Risk Factor	Plant C		Plant D		$\chi 2$	P-value
	No. Examined	No. (%) Positive	No. Examined	No. (%) Positive		
Meat sample	24	5(20.83)	24	0 (0)	5.05	0.02
Hand swab	24	0 (0)	24	0 (0)		
Cloth swab	24	0 (0)	24	0 (0)		
Hook swab	24	7(29.17)	24	1 (4.17)	4.58	0.03
Knife swab	24	1 (4.17)	24	0 (0)	1.00	0.31
Meat mince	24	0 (0)	24	0 (0)		
Cooler	24	0 (0)	24	0 (0)		
Axe swab	24	0 (0)	24	0 (0)		
Balance swab	24	1 (4.17)	24	2 (8.33)	0.34	0.56
cutting board	24	4 (16.7)	24	0 (0)	4.03	0.04
Total	240	18 (7.5)	240	3 (1.25)		
Overall occurrence of *E. coli* O157:H7			480	21 (4.38)		

Assessment of meat handling practices of Haramaya district

Sociodemographic characteristics of abattoir, retailers and cafeteria workers

The Table 10 shows the Sociodemographic information of abattoirs, meat retailers and student's cafeteria workers were interviewed at Haramaya District abattoir, meat retail shops, and student cafeterias. The result revealed that 56.25%, 12.5%, 6.25% and 18.75% were illiterate at Haramaya town abattoir, Haramaya University abattoir, meat retailer and Cafeteria workers respectively. Respondent of 56.25% and 18.76% from abattoir and meat retailer shops were illiterate.

Table 5: Descriptive frequency of sociodemographic characteristics of abattoir, retail workers and cafeteria workers

Variable	Categories	Plant A	Plant B	Plant C	Plant D
		No. (%)	No. (%)	No. (%)	No. (%)
Level of education	Illiterate	9(56.25)	2(12.5)	3(18.75)	3(18.75)
	Primary	2(12.5)	4(25)	1(6.25)	4(25)
	Secondary	4(25)	8(50)	4(25)	2(12.5)
	Diploma	1(6.25)	2(12.5)	8(50)	7(43.75)
Employment status	Temporary	8(50)	4(25)	14(87.5)	2(12.5)
	Permanent	8(50)	12(75)	2(12.5)	14(87.5)

Experience, Training, Health education and awareness of foodborne Diseases of workers processing plant establishment

Table 6: Experience, Training, Health education and awareness of foodborne Diseases of workers processing plant establishment

Variables	Categories	Plant A	Plant B	Plant C	Plant D
		No. (%)	No. (%)	No. (%)	No. (%)
Medical checkup	yes	3(18.75)	7(43.75)	0(0)	11(68.75)
	No	13(87.5)	9(56.35)	16(100)	5(31.25)
Health certificate	yes	0(0)	2(12.5)	2(12.5)	11(68.75)
	No	16(100)	14(87.5)	14(87.5)	5(31.25)
Training attended	Yes	1(6.35)	5(31.25)	3(18.75)	11(68.75)
	No	15(93.75)	11(68.75)	13(87.5)	5(31.25)
Knowledge FBD	Yes	5(31.25)	11(68.75)	4(25)	11(68.75)
	No	11(68.7)	5(31.25)	12(75)	5(31.25)
Action taken during sick	Go to work	14(87.5)	4(25)	9(56.25)	14(87.5)
	Report to head	2(12.5)	12(75)	7(43.75)	2(12.5)

Based on the information concerning with medical test, training and experience of check lists and interviewed the majority of respondents 100%, 81.25% and 56.25% have not taken medical test at retailer and in both abattoir respectively and also 93.75% and 68.75% did not take training at both abattoir. Most of the respondents about 68.75% did not have knowledge of food borne disease in abattoir.

Hygiene and Sanitation of workers regarding meat safety and handling practices at processing plant establishment: All workers from meat retail shops and Haramaya University student cafeteria always wear gown and 43.75% of worker from abattoir did not wear gown and 93.76%, and 87.5% of workers from retailer and abattoir clean their hands before and after meat handling and 43.75% wear jewelry in abattoir. Respondents from cafeteria 87.5% wash their hand before, between, and after. About 87.5% of the respondents from cafeteria wash equipment daily. Similarly, 81.25% of respondents from Haramaya town abattoir wash washing protective cloths two times a week as shown in the following Table 7.

Table 7: The frequency test of workers hygiene and sanitation regarding meat safety and handling practices at processing plant establishment using descriptive statistics

Variables	Categories	Plant A	Plant B	Plant C	Plant D
		No. (%)	No. (%)	No. (%)	No. (%)
Wear gown	Yes	9(56.25)	15(93.75)	10(62.5)	15(93.75)
	No	7(43.75)	1(6.25)	6(37.5)	1(6.25)
Wearing of jewelry	Yes	6(37.5)	3(8.75)	9(56.25)	1(6.25)
	No	10(62.5)	13(81.25)	7(43.75)	13(81.25)
Hand washing interval time	Before and after	14(87.5)	3(18.75)	10(62.5)	2(12.5)
	Before, between and after	2(12.5)	13(81.25)	6(37.5)	12(75)
Frequent of washing clothes and equipment protective	Daily	6(37.5)	12(75)	2(12.5)	8(50)
	Once a week	9(56.25)	4(25)	6(37.5)	3(18.75)
	Twice per week	1(6.25)	0(0)	8(50)	5(31.25)

Discussions

The goal of the current study was on assessment of meat handling practices and occurrence of *Escherichia Coli* O157:H7 in beef meat and meat associated contact surfaces along the meat supply chain at Haramaya town abattoir, butcher shops, meat distributors and the student cafeteria in Haramaya District were 25(10.08%), 18(7.5%), 10(4.03%) and 3(1.25%) positive for *E. coli* O157:H7 respectively.

The present study shows that the total prevalence of *Escherichia Coli* O157:H7 at both plant A, B, C and D were 56 (5.73%). The prevalence was higher at Haramaya town 25 (10.08%) than at the Haramaya University abattoir 10 (4.03%). This might be due to the professional experience, hygiene, and sanitation status of the workers, because most of the workers did not get training on food borne diseases and workers have done carelessly in abattoirs and retail shops. This might be due to cross contamination of beef meat and meat associated contact surfaces along the supply chain in abattoirs and meat retail shops. This assumption was consistent with previous research of (Mekonnin *et al*., 2013) [64] that indicates of prevalence of *E. coli* O157: H7 in cattle feces and contamination of meat from hide and carcasses of animals at slaughter (Sebsibe and Asfaw, 2020) [114]. There were 56 instances of *Escherichia Coli* O157:H7 with the total occurrences 5.73% among four sites at Haramaya District. Among of the result obtained, 25(10.08%) and 10 (4.03%) of *Escherichia Coli* were isolated from Haramaya town abattoir and Haramaya University abattoir out of 496 examined samples respectively.

At Haramaya town abattoir, 7 (22.58%) from feces, 5 (16.12%) from skin swabs, 4 (12.9%) from meat samples, 4 (12.9%) from hook swabs, 2 (6.45%) from hands swab, 1 (3.23%) from boot swab, 1 (3.23%) from cloth swab and 1 (3.23%) from a knife swab samples were positive for *Escherichia Coli* O157:H7. At Haramaya University abattoir, 3 (9.67%) knife swab, 3 (9.67%) hand swab, 2 (6.45%) cloth swab and 1 (3.23%) fecal sample were isolated and identified positive for *Escherichia Coli* O157:H7.

The current study's findings indicated that the fecal samples from two slaughterhouses in the Haramaya District sample were significant (p<0.05). The current study result was conducted in the summer at the Haramaya town abattoir, which is season of high prevalence in feces. Transporting the stressed animal prior to slaughterhouse was also increases *E. coli* O157:H7, which could account for this discrepancy (Omisakim *et al*., 2003) [75] due to higher sample quantities, transporting the animals may result in an increases shedding of microbial burdens like *E. coli* O157:H7 in feces (Omisakim *et al*., 2003) [75]. According to the previous study of (Chapman *et al*., 2002) and (Reid *et al*., 2002) [83], amount of *Escherichia Coli* O157:H7 shed from animal feces were varies significantly depending on the abattoir's conditions, age of animals and types of feed used by animals.

Another factor is that the animals in Haramaya town were immediately bought from the market and slaughtered as soon as they arrived at the abattoir. Since most of the animals in the market places are of diverse origins, they mount one another. This causes the animals to fight, which causes stress and the release of bacteria shed through feces from animal feces varies significantly depending on the abattoir's conditions and the age of the animals (Reid *et al*., 2002) [83].

When compared with the previous obtained results in certain areas around the world, the current study was found to have a lower prevalence rate. Whereas in Ethiopia, sheep feces showed a 28% prevalence rate (Solomon *et al*., 2019) [99], 40.4% in UK (Elder *et al*., 2000) [85], 27.8% in USA (Robert *et al*., 2000) [85], 23.7% in the UK (Strachan *et al*., 2002), 28% from the USA (Mozhgan *et al*., 2019) [69] and 35% in Nigeria (Akanbi *et al*., 2011) [6]. Most of the previous studies demonstrated that the frequency shedding of *E. coli* O157:H7 from animal feces varies greatly with time of sample collection, animal age and diet of animals used (chapman *et al*., 2001) [26].

According the present study the isolation of *E. coli* O157:H7 from feces sample was feces sample was different from previous studies because of sampling time, sample size, the season of sample collection the husbandry condition of the animal, as well as differences in abattoir workers' personal hygiene and the handling of animals before they were slaughtered. At Haramaya town abattoir, the result obtained from hide swab revealed that more significantly than Haramaya University abattoir (p<0.05). There was poor hygiene in the treatment of the workers at Haramaya town abattoir. Due to poor hygiene of workers at abattoir, animal hide may pick up *E. coli* O157:H7 from a variety of sources, including soil, water, feces, and others. An animal's skin may become polluted by feces from both that animal and other animals.

This was made possible by the fact that animals in Haramaya town were bought from the market and taken directly to the slaughterhouse. Whereas one animal's feces can contaminate many hides, multiple animals' feces can contaminate hides during loading onto vehicles. Due to a lack of lairage, the majority of animals were carried to the butchers from the market, which was a significant source of hide contamination.

Therefore, because animals are in closer proximity to one another during transit and in lairage or laundry, cross

contamination of skins may happen. Transportation of beef cattle to lairage at for slaughter can lead to an increases of prevalence and extent of *E. coli* O157:H7 on beef hides (Arthur *et al*., 2002) [12]. As a result, animals would disseminate *E. coli* O157:H7 through their feces and hides of animals easily contaminate with feces. This may increase the prevalence *E. coli* O157:H7 on hide related feces (Solomon *et al*., 2019) [99]. When compared to a previous study the current finding obtained from hide (16.12%) was high compared with various region of Ethiopia.

Compared to the previous studies, the current result was a low prevalence of *E. coli* O157: H7 was found such as one that found 27.5% of *E. coli O157: H7 from* Nigeria (Akanbi *et al*., 2011) [6], 28.8% in the UK (Small *et al*., 2002) [97], 28.2% in Novi Sad, Serbia (Nastasijevic *et al*., 2008), and 18% in the UK (Ransom *et al*., 2002) [82].

The difference of variation obtained in current study and the previous result were due to cross contamination of carcasses due to the use of the same knife for flaying and evisceration, cross contamination of carcasses with fecal contents when puncturing of intestinal contents due to carelessness of abattoir workers, and transportation of the animal prior to the slaughterhouse, loading and unloading of animal during transit, environmental conditions and meat processing condition at the abattoir and danger of cross-infection of the carcass and subsequent contamination would all factors that contribute the significant difference (p<0.05).

Regarding meat source, Haramaya town abattoir 4 (12.9%) had a greater than Haramaya University Abattoir. Compared to earlier research in various regions of Ethiopia, the current obtained result from meat (12.9%) was lower with reference to the meat source.

For example, the prevalence of *E. coli* O157:H7 reported in Nigeria was 53% (Dahiru *et al*., 2008) [28], 27.5% from cow meat in Iran (Mozhgan *et al*., 2019) [69] and 18% from meat samples in Mekelle (Balcha *et al*., 2014) [36].

Generally, other contributing sampling technique, farming and slaughter practices and sampling methodologies may increase incidence rate of *E. coli* O157:H7. For instance, *O157* was much more common when cattle were transported or lairage at abattoirs, according to (Avery *et al*., 2002) [116], and (Abraham *et al*., 2002) showed varying incidence rates from farm to packing. The act of slaughtering animals also affects the spread and cattle dressing can direct contact between the hide and the meat as well as through the use of equipment and utensils (Tutenel *et al*., 2003) [107].

The dangers of pathogen contamination are higher in slaughterhouses where slaughterhouse operations are horizontal, because in contemporary abattoirs, leakage from intestines on the meat during evisceration frequently occurs, and contamination of the meat during the evisceration process is extremely high. In regards to Hook, Haramaya town Abattoir 4 (12.9%) was the location of substantially greater *E. coli* O157:H7 contamination than Haramaya University Abattoir 0% (p<0.05).

This was caused by the frequent washing of equipment or the length of time between washings of equipment in abattoirs like hooks, axes, and cutting boards, which were washed 12.5% daily, 12.5% once per week, 68.75% twice per week and 6.25% three times per week at Haramaya Town Abattoir and 25% daily, 18.75% once per week, twice per week and once every two weeks. When compared to the findings of the previous investigation, the much greater detected of abattoir on Hook was higher in various regions of Ethiopia.

Of 480 samples examined, 18 (7.5%) and 3 (1.25%) at student cafeteria and meat retailer shop, respectively. Among the results obtained, 29.17% from hook swab sample, followed by 20.83% from meat swab sample, 16.7% from table or cutting board swab sample, 4.17% from knife swab sample, and 4.17% from balance weight swab were positive at meat retail shops and at the student cafeteria, 2 (8.33%) of the balance weight swab sample and 1 (4.17%) were positive.

Regards Hook, the source of significantly higher contamination of found meat retailer shops was 7 (29.17%) from Hook swab samples, 5 (20.83%) from meat samples, and 4 (16.7%) from table or cutting board swab samples, which was (p<0.05) than student cafeteria 0%. This was due to the workers' personal hygiene and sanitation, professional experience, lack of training, lack of awareness about health education, and awareness of foodborne diseases. There were differences between the meat retailer shop and the student cafeteria regarding the safety of the meat at both locations. 56.25% of the respondents to the respondents to a survey at a meat retailer and of those who did, 43.75% of the respondents' clothes were dirty. The outcome complied with Hailesilassie *et al*. (2013), who discovered that a greater percentage of employees from particular butcher shops in Ethiopia do not use safety clothes.

When compared with other countries, the Ethiopian abattoir workers compared with Kenya, less than half of employees always wore safety clothes (Elizabeth *et al*., 2017) [35]. For instance, only 87.5% and 0% of the staff at the student cafeteria and meat retailer shops washed the equipment (hooks, axes and cutting boards) on a daily basis, respectively. By contrast, 56.25% of workers of student's cafeteria had awareness of food-borne diseases.

The current study result 29.17% from hook swab samples was higher when compared in some parts of Ethiopia. For example, 0% in Jijiga town retailer shop, 6.6% in Jijiga municipal abattoir (Henok *et al*., 2015) [49] and 0% in Kenya at meat retailer (Kago, 2015) [56].

According the current study *5*(20.83%) from sample at meat retailer shop was significant (p<0.05) when compared with student cafeteria. In terms meat source, the retailer shops 5(20.83%) had a higher than the student cafeteria (0%). The current result obtained at the meat retailer shop was lower when compared with the previous study in Ethiopia. For example, the present result was slightly related to the 21.9% reported in beef meat at meat retailer shops in Addis Ababa by (Tizeta *et al*., 2014) [106]. Also, the current result was high when compared with previous studies in Ethiopia like 14.29% at Arada kifla ketema in Addis Ababa (Aklilu *et al*., 2022) [7], 4.5% in butchers shops in Jimma town (Sebsibe and Asfaw, 2020) [114], 5.6% of meat samples (Eyob, 2020), 2% of meat samples at retailer shops in Jimma town (Atnafie *et al*., 2017) [15] and 4.5% from carcass swab (Ashenafi *et al*., 2017) [13]. The big difference in variation between the current results and the previous studies was due to differences in sample size, the hygienic conditions of meat preparation and processing, as well as the storage meat.

When compared to student cafeteria, the 16.7% positive cutting board swab at a meat retailer shop was significant at p-value 0.05. This was due to the personal hygiene and

sanitation of workers at butcher shops and student cafeterias regarding meat safety, as was discussed above

The current result obtained (16.7%) from cutting boards at butcher shops was high when compared with the previous studies in different places; 4% in Addis Ababa, 3.3% in Bishoftu, and 6.67% in Holeta (Ashenafi *et al*., 2017) [13], 0.87 in Addis Ababa (Woynshet, 2014) [113], 10% from cutting boards in Jimma (Mengistu and Eyob, 2020) and 3.6% from cutting in central Ethiopia (Ashenafi *et al*., 2017) [13]. Generally, with regard to the sample sources, the current result obtained at Haramaya town abattoir was 25 (10.08%), 10.4% (Abebe *et al*., 2014) [2], 10.2% (Bekele, T., Zewde, G., Tefera, G., *et al*., 2014) and 9.1% Ambo town at abattoir and retail meat shop (Nega *et al.*, 2014). The present study results obtained at Haramaya town abattoir were high when compared with the previous studies in some parts of Ethiopia. For instance, 2.8% at Hawassa town abattoir (Atnafie *et al*., 2017) [15], 2.65% at Haramaya university slaughterhouse before eight years (Taye *et al*., 2013) [65], 6.0% in Jimma town (Sebsibe and Asfaw, 2020) [114], and the current result at Haramaya town abattoir compared with the results reported from different regions in Ethiopia, like 13.3% in beef in Ethiopia (Tizeta *et al*., 2014) [106], 14.6% in sheep meat (Tizeta *et al*., 2014) [106], 11.11% from the abattoir in Jigjiga town (Henok *et al*., 2015) [49].

With regard to the present result obtained total Haramaya University abattoir was (4.03%) is almost related 4.2% (Hiko A, Asrat D, Zewde G (2008) [5] in Modjo and Bishoftu (Debrezeit), and the result was low compared with the previous study. For instance, (7.2%) in Ambo town (Tadesse *et al*., 2021), 11 (5.7%) from the abattoir in Addis Ababa (Tizeta *et al.,* 2014) [106], 5.5% from carcass swab at Debrezeit (Tassew, 2015) [14].

The present result obtained at meat retailer shops was 18 (7.5%), which was low compared with the previous reported result by Beckley *et al*. (2014). 21.9% in Addis Ababa at meat retailer shops, 9.3% at butchers shops Hiko A, Asrat D, Zewde G (2008) [5] in retail raw Ethiopia, 19.4% in retail shops in Ambo town reported by (Tadese *et al*., 2021) [72] and 6.67% Jigjiga town retail meat shop reported by (Ayalew *et al.*, 2015) [49].

The present result obtained at Haramaya University abattoir (4.03%) was high when compared with previously reported in most countries. For instance, 3.43% at retail shops in Nigeria (Itelima and Agina, 2011) [55], 3.6% in Dagoretti in Kenya reported by (Kago, 2015) [56], 3.75% reported from Gaborone, Botswana by (Magwira *et al*., 2005) and 3.2% reported from butchers shops in Ireland by (Cagney *et al*., 2004). High in the current study because high values indicate that the point plant shop as well as personal hygiene and sanitation of workers at abattoirs (processing plant) and butcher shops regarding meat safety

The current prevalence obtained at student cafeteria 1.25% was little bit high compared with 0.44% from Algeria in frozen meat (Barka and Kihal, 2010), 0.8 % in central region of Ethiopian from beef contaminated at butcher shops and restaurants (Abdissa. R, Haile, W., Fite, A. T. (2017) and the present result was in line with 1.7% in goat meat and 1.3% in camel meat in Iran reported by (Hajian *et al*., 2011) [46], 0.29% (Itelima and Agina, 2011) [55] from Nigeria in beef meat and 1.6% in Eldoret in Kenya at a meat retail shop reported by (kago, 2015) [56]. With regard to the current result obtained for *E. coli* O157: H7 at students' cafeteria, 1.25% was low when comparing the result reported in previous studies in different countries. For instance, 3.6% of Dagoretti in Kenya (Kago, 2015) [56] and 5.5% in Ethiopia reported by (Messele *et al*. (2017).

The present study result showed a difference in variation compared with other studies. This may be due to the difference in isolation procedures, method of meat handling at processing plants, the conditions of the slaughterhouse, and skin contact to meat. Most of the previous studies made the same assumption for the same reason (Eshetu *et al*., 2021).

Of 976 examined samples, overall occurrence of *Escherichia Coli* O157:H7 in beef meat and meat contact surfaces in four study sites at Haramaya District was 56 (5.73%). The current result is observed in line with different previous studies in Ethiopia, such as the 5.4% in Jimma town reported by (Sebsibe and Asfaw, 2020) [114]. The overall result observed in the current study was high when compared with the previous study in some parts of Ethiopia. 4.2% from Modjo and Bishoftu (Hiko *et al*., 2008) [5], 4.2%, reported from Hawassa (Atnafie *et al*., 2017) [15] and 6.3% from Dulet and 3.1% from Kurt from Arsi zone reported (Minda and Shimelis, 2021) [66].

The current result obtained 5.73% were low compared with results reported from different region and countries. For example, 10.4% from Tigray reported by (Abebe *et al*., 2014) [2], 9.1% from Ambo town (Nega *et al*., 2021) [72], 8% in beef from Modjo (Hiko *et al*., 2008) [5], 9.6% in Iran (Tahamtan *et al*., 2006) [102], 8.8% from South Africa (Abong, 2008) [3], 8.9% reported by (Hajian *et al*., 2011) [46] and 13.3% reported from China (Zhang *et al*., 2015). 6.7% was reported from Mekelle (Mekonnin *et al*., 2013) [64].

Generally, regarding with sample types result obtained shows that statistically significance different at Haramaya town abattoir, Haramaya University abattoir, meat retail shops and student cafeteria. The level of significance was found on meat which was the p-value of 0.02 as shown in Table 7 on page 26 above. This is due to poor hygienic condition of workers and lack of training on meat handling practices in four processing plants.

In four processing plants most of the respondents responded the slaughterhouse workers, butchers, meat handlers and meat sellers do have enough facilities like knife sterilization and carcasses approval room, no enough protective facilities and poor management. Both abattoirs and meat retail shops have no mechanism of ensuring sanitation standards, proper waste disposal mechanism. Therefore, there are opportunities of contamination of slaughter facilities which in turn contaminate which bring to contamination of the meat with *E. coli* O157:H7 in processing plants.

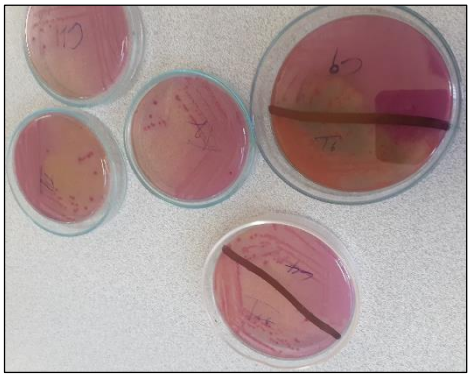


Fig 1: *Escherichia Coli* o157: H7 cultivated on MacConkey Agar

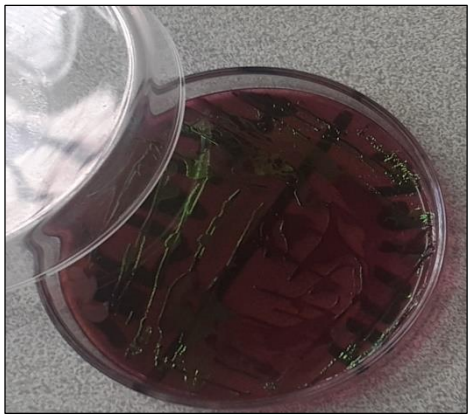


Fig 2: Image of *E. coli* on EMB. Green Metallic sheen color

Fig 3: *Escherichia Coli* O157:H7 Indole test positive result

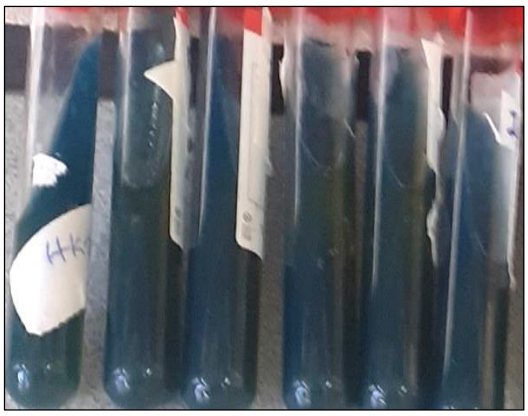


Fig 4: *Escherichia Coli* O157:H7 Cimon Citrate utilization test

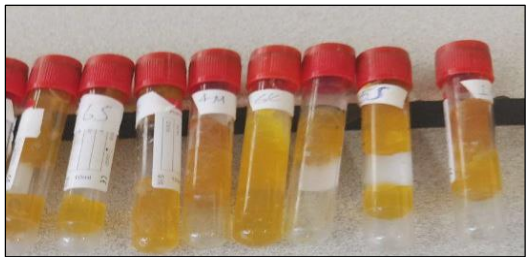


Fig 5: *Escherichia Coli* O157:H7 Triple Sugar Iron test

Fig 6: *Escherichia Coli* O157:H7 on Sorbitol MacConkey Agar

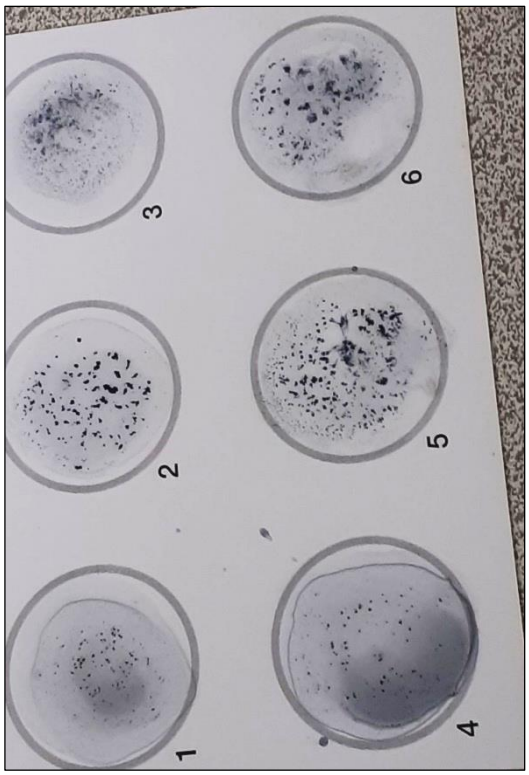


Fig 7: Result of *Escherichia Coli* O157:H7 latex agglutination test

Conclusion and Recommendation

Escherichia Coli O157:H7 was isolated and identified as high prevalence in the feces, followed by Hide and meat samples collected from beef meat and meat associated contact surfaces at Haramaya District, Eastern Ethiopia. The study revealed that the two processing plants (Haramaya town abattoir and Haramaya University abattoir), meat retail shop and Haramaya University student cafeteria did not meet the required sanitation and hygiene standards and also there was cross contamination of beef meat with *E. coli* O157:H7 from contact surfaces along meat supply chain. The worker did not get proper training and monitoring of meat handling to ensure sanitation and hygienic meat handling practices to provide good quality of meat. The slaughterhouse and meat retail shops in the study areas did not pay attention to national and international regulation and guidelines.

Based on the above conclusions, the following recommendation should be forwarded:

- Improving practices and knowledge of meat handling practices of workers and butchers about safe meat, preparation and distribution at processing plants.

- Slaughterhouse, meat retail shops and workers should give attention to national and international guidelines.
- Proper training on awareness of foodborne diseases, meat handling practices and hygiene and sanitation should be deliver from time to time for slaughter workers, butchers and meat retailer/seller should be given.
- Farther research should be recommended to validate sources and point of meat contamination (farm to fork concept) at meat processing establishment.
- Identification of *Escherichia Coli* molecular genetic characterization should be done with an antibiotic susceptibility profile.

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