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Original Research

Knowledge, Attitude, Hygiene Practices, and Enumeration of Salmonella from Raw Meat at Retailer Shops in Chelenko Town, Eastern Ethiopia

Bayan A. Mumed, DVM, MSc[1*]; Mohammedkemal M. Ame, MSc[2]; Fathi M. Sayaka, DVM[1]; Hamza M. Yuya, DVM[1]; Ahmed Adame, BVSc[1]; Mohammed Bedruddin, DVM[3]; Megersa Abdulhamid, DVM[4]; Mohammed Jemal, DVM[5]; Abrahim Eliyas, BVSc[6]

[1]*Department of Veterinary Medicine, Chelenko Veterinary Clinic, Meta Woreda, Eastern Harerghe, Ethiopia*
[2]*Department of Veterinary Public Health, Furda Veterinary Clinic, Bedeno Woreda, Eastern Hararghe, Ethiopia*
[3]*Department of Veterinary Medicine, Kurfa Veterinary Clinic, Kurfa Woreda, Eastern Harerghe, Ethiopia*
[4]*Department of Veterinary Medicine, Veterinary Clinic, Hawi Gudina Woreda, Western Harerghe, Ethiopia*
[5]*Department of Veterinary Medicine, Office of Livestock Development, Animal Health Process Manager, Haramaya Woreda, Eastern Harerghe, Ethiopia*
[6]*Department of Veterinary Medicine, Veterinary Clinic, Tulo Woreda, Western Harerghe, Ethiopia*

[*]***Corresponding author***
Bayan A. Mumed, DVM, MSc
Department of Veterinary Medicine, Chelenko Veterinary Clinic, Meta Woreda, Eastern Harerghe, Ethiopia; Tel. +251920920732; E-mail: drbayan2017@gmail.com

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ABSTRACT

Aim
Salmonella has been identified as the primary contributor to foodborne illnesses, posing a significant public health issue due to its high contamination rates.

Methods
A cross-sectional study was conducted from July 2022 to December 2022 to isolate and determine the burden of Salmonella in goat meat at retail shops and to identify knowledge, attitudes, and hygienic practices in Eastern Ethiopia. A total of 224 samples were collected from goat meat, and environmental samples (cutting board, knife, worker's hand, and hook) were examined for the prevalence of Salmonella using conventional microbiological procedures. All samples underwent serial dilution to determine Salmonella loads in goat meat from the retailer's houses. Additionally, 33 retail shop workers with different demographics were interviewed regarding their knowledge, attitudes, and practices related to Salmonellosis.

Results
The results revealed that out of 224 goat meat and environmental swab samples examined, the prevalence of Salmonella was 26.78%, 31.6%, 19.6%, 22.2% and 15.8% for goat meat swabs, cutting boards, hand swab samples, knife, and hook swab samples, respectively. The total average loads of Salmonella on different samples were found to be 6.88×10^5 cfu/mL, 6.09×10^5 cfu/mL, 6.51×10^5 cfu/mL, 4.59×10^5 cfu/mL and 3.28×10^5 cfu/mL for meat swab samples from retailers, hand swab samples, cutting boards, knife swabs, and hook swab samples, respectively.

Conclusion
The study showed that the hygienic status of retail shops in the study area is poor, and the prevalence and load of Salmonella are high. Based on these results, it is recommended to raise awareness to reduce the prevalence of Salmonella in goat meat and decrease bacterial loads. Additionally, the responsible authorities should coordinate with retailers and shops to enforce good hygienic handling practices.

Keywords
Salmonella; Retailer shop; Raw goat meat; Hygiene; Chelenko; Enumeration.

INTRODUCTION

Food-borne diseases occur as a result of the consumption of contaminated foodstuffs, especially animal products, and represent a significant global public health issue.[1] These illnesses are particularly common in developing nations, notably in Africa, due to prevalent issues with poor food handling, inadequate sanitation, insufficient food safety measures, limited resources, and low awareness among food handlers.[2] Additionally, environmental factors, such as the tools used during the slaughter process, can introduce microorganisms

that pose a risk to meat processors, originating from animal waste and skin. These microorganisms may also be transferred to the carcass during skin removal and evisceration.[3] The term "food-borne diseases" or "food-borne illnesses" refers to gastrointestinal issues that develop shortly after consuming contaminated foods.[4]

The most prevalent zoonotic bacterial disease in humans is gastroenteritis, brought on by pathogenic bacteria called Salmonella that reside in the gastrointestinal tract.[5] Salmonella species are facultative intracellular, gram-negative, rod-shaped bacteria that can infect a wide range of hosts.[6] Due to their significant morbidity and financial burden, Salmonella infections (also known as Salmonellosis) are regarded as the most common food-borne disease worldwide.[7] Foodborne Salmonellosis is frequently linked to consuming contaminated animal products, which typically come from sick animals used in food production or from the contamination of carcasses or edible organs.[8] Salmonella species have been implicated in the majority of scientifically documented cases of meat poisoning in the developed world. The main causes of Salmonella infection in meat animals are the consumption of contaminated foods and inadequate rearing practices.[9]

Salmonella infection appears to be one of the most frequent examples of an intestinal disease that is passed from animals to people. Humans and animals transmit the infection through feces-oral contact as well as by consuming food items such as meat, dairy, and eggs.[10] Salmonella can spread by not thoroughly cleaning surfaces used to prepare raw meat as well as by not washing fresh produce before eating it. Food can also become contaminated by food handlers who do not thoroughly wash their hands with soap after handling raw meat or using the lavatory. Although Salmonella illnesses can also be brought on by contact with sick people, animals, or other waste, they are most frequently caused by contaminated food.[11]

Numerous techniques have been developed for the detection, identification, and molecular characterization of Salmonella species.[12] Salmonella can be isolated and confirmed in the sample using culture, which can take 4 to 7-days.[13] Typically, Salmonella is isolated using conventional culture techniques such as non-selective pre-enrichment, selective enrichment, and plating on selective and differential agars. Subsequently, biochemical and serological tests are performed to confirm suspected colonies. More recently, several alternative techniques, such as immunoassays, nucleic acid hybridization, and polymerase chain reaction (PCR) methods, have been developed for the detection of Salmonella in food.[14]

According to numerous studies, Salmonella has been discovered in a variety of locations around the world in animals that produce food and animal products.[15] Goat meat has also been linked to Salmonella food contamination.[6] In Ethiopia, only a few studies have been carried out with the aim of isolating Salmonella from goat meat, and Salmonellosis as a disease, particularly the isolation of Salmonella from goat meat at retail shops, has received very little attention.[16] Due to customary practices and a lack of legislation, the majority of Ethiopians slaughter small ruminants in their backyards instead of slaughterhouses.[17] However, research on the prevalence of Salmonella in goat meat at retail establishments in eastern Ethiopia is limited.

The objectives of the study are as follows: Isolate Salmonella from raw goat meat in Chelenko town, determine contamination load, identify sources, and assess hygienic handling practices among food handlers in retailer shops.

MATERIALS AND METHODS

Study Area

The study was conducted from July 2022 to December 2022 in Chelenko Town, Eastern Hararge Zone, in the Oromia regional state of Ethiopia. Chelenko Town is situated 445 km to the east of the capital city, Addis Ababa, and 80 km west of Harer town. Geographically, it is located between 9°7'55" to 9°28'45" N latitude and 41°31'40" to 41°52'30" E longitude. The Woreda is bordered by Goro Muti Woreda in the south, Deder Woreda in the southwest, Goro Gutu in the northwest, Bedeno Woreda in the southeast, Kersa Woreda in the northeast, and the Somali Region in the north (Figure 1).

The altitude of Metta Woreda ranges from 1311-2830 meters above sea level. Its annual rainfall varies from 600-900 mm, and the temperature ranges between 15 °C and 37 °C.[18] The Woreda is composed of 39 rural kebeles and 3 urban kebeles (two in Chelenko and one in Kulubbi), making a total of 42 kebeles.[18]

Study Design

A cross-sectional study was conducted from July 2022 to December 2022 to isolate and identify Salmonella from goats at retail shops and determine possible sources of contamination. Additionally, an observational and descriptive study was carried out using a checklist and questionnaire survey to assess the hygienic practices of meat handlers working at butchers.

Sample Size Determination and Sampling Techniques

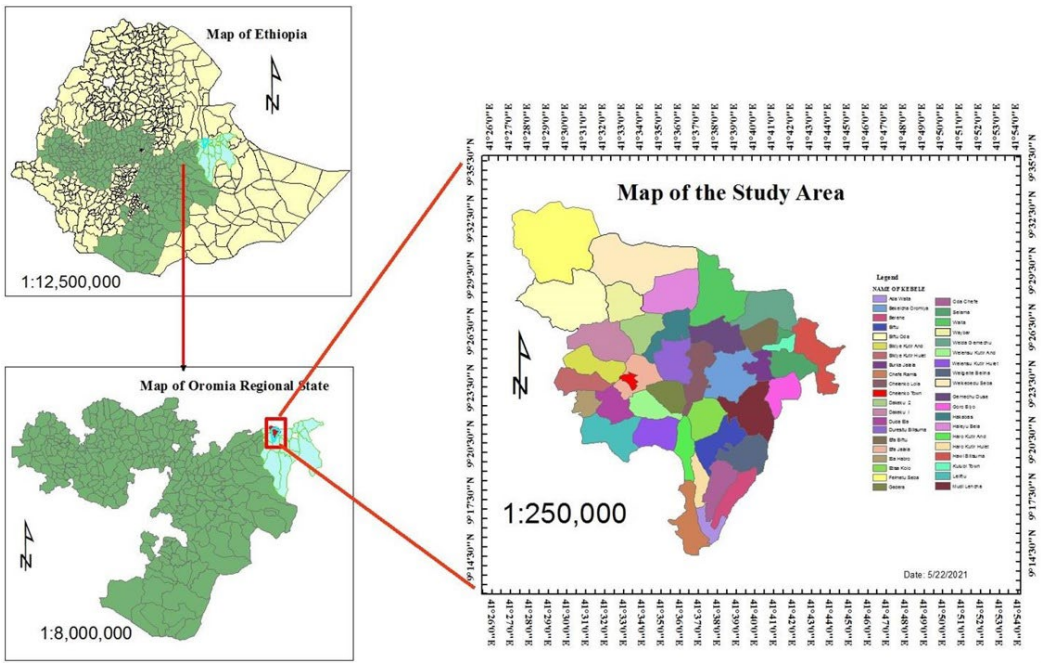
Since there was no previous prevalence estimate in this study area, the prevalence of Salmonella from raw goat meat at the Dire Dawa municipal abattoir was used for sample size determination. A previous cross-sectional study indicated a prevalence of 17.7% for Salmonella in raw goat meat.[19] Therefore, we employed the formula from Thrusfield[20] and Techasaensiri et al[21] to estimate the sample size with a 95% confidence interval and 5% precision.

$$n = \frac{1.96^2 \times P_{exp} \times (1\text{-}Pe_{xp})}{d^2}$$

Where:
n=required sample size,
Pexp=expected prevalence,
d=the desired absolute precision of 0.05.

Accordingly, the number of samples needed to determine the prevalence of Salmonella in goat meat at retail shops was

Figure 1. *Map of the Study Area*



determined to be 224.

For the questionnaire survey, the sample size approximation was based on a 5% standard error (SE) with 95% confidence intervals. Due to the limited number of butcher house workers, all 33 employees involved in meat-handling activities were included in the study. A structured questionnaire was prepared for the butcher house workers.

Sample Collection and Transportation

Carcass swab sampling: During each visit, four different sites of the carcass (namely, the ribs, neck, flank, and hind leg) were swabbed using the method described in International Organization for Standardization (IOS).[22] A sterile template measuring 10×10 cm was placed on the carcass to cover an area of 100 cm^2. For each sampling area, sterile cotton wool swabs rolled on wooden sticks were moistened in 10 mL of buffered peptone water. The swabs were then rubbed over the entire selected area with continuous pressure for 30-seconds.

After completing the rubbing process, the wooden sticks were broken by pressing them against the inner wall of the test tube and then disposed of. The cotton wool swabs were transferred to screw-capped test tubes containing the buffered peptone water. Subsequently, the same pressure was repeated to sample each location with dry swabs. The swab samples were placed into the same test tube filled with 10 mL of buffered peptone water. The test tube was shaken vigorously for 2-minutes before transportation.

Environmental sampling: During each visit to the butcher house, environmental samples were collected from the hands of the butcher shop workers (56), and samples were also collected from equipment such as knives (18), cutting boards (19), and hooks (19). For knives, combined samples were collected from both the blade and handle. The swabs used for sampling were returned to a test tube containing 10 mL of sterile buffered peptone water (BPW).

A second dry, sterile cotton swab of the same type was used as before, and it was used to swab over the entire sampled area as described above. This second swab was then placed into the same container as the first swab.

All the collected samples were transported to the Hirna Regional Veterinary Microbiology Laboratory (HRVL) using an icebox with ice packs to maintain proper temperature conditions. The samples were analyzed upon arrival at the laboratory or within 24-hours of sampling.

Questionnaire Survey and Observation

The data was collected by administering structured questionnaires to butcher shop workers. The questionnaires were guided by a checklist that included various items related to the study, such as the general conditions of the butcher shops, facilities, general hygienic conditions, processing practices, personnel, equipment, transportation, and demographic information of the participants.

A total of 33 respondents from the retailer were included in the study. The personnel responsible for the processing of goat meat were interviewed, and the required samples were taken after obtaining oral consent from the participants.

Before the start of data collection, the questionnaires were translated into Afaan-Oromoo, and the interviews were conducted using the local language. Personal observations were also made, which included assessing the hygienic practices in the butcher house and the personal hygiene of the butcher house workers.

Laboratory Analysis Methods

Isolation and identification of Salmonella: We isolated and identified Salmonella using the technique recommended by the IOS,[22] and we prepared the bacteriological media following the manufacturer's recommendations.

In the first stage, the samples in BPW were incubated for 18±2-hours at 37±1 °C to promote the proliferation and regeneration of damaged cells. After the non-selective pre-enrichment stage, 1 ml of the pre-enriched sample was transferred and mixed aseptically into a tube containing 10 mL of Rappaport-Vassiliadis medium (RV) broth. The inoculated tubes were then incubated at 37±1 °C for 18-hours to favor the growth of Salmonella.

We transferred a loopful of inoculum from the RV broth and streaked it onto xylose lysine desoxycholate (XLD) agar plates. The plates were prepared following the manufacturer's directions. The plates were incubated at 37±1 °C for 24-hours. If there was no growth within 18 to 24-hours, the plates were re-incubated for an additional period.

After proper incubation, the plates were examined for the presence of suspected Salmonella colonies. If growth was slight or if no typical colonies of Salmonella were present on the agar plates, they were re-incubated at 37 °C for another 18 to 24-hours. After incubation, the plates were examined for the presence of typical and suspect colonies.

Typical colonies of Salmonella grown on XLD agar have a black center and a lightly transparent zone of reddish color due to the color change of the media.[22] H_2S-negative variants grown on XLD agar appear pink with a darker pink center. Lactose-positive Salmonella grown on XLD agar appear yellow with or without blackening.

The suspected Salmonella colonies were subcultured on nutrient agar for further biochemical confirmation tests.

Biochemical identification: For biochemical confirmation, three typical or suspected pure Salmonella colonies were selected from each selective plating medium. These selected colonies were streaked onto the surface of pre-dried nutrient agar plates and incubated at 37±1 °C for 24±3-hours. The pure cultures on nutrient agar were then used for biochemical confirmation.

The biochemical tests included the following:

- Glucose, lactose, and sucrose fermentation and gas and H_2S production in triple sugar iron agar (TSIA).
- Urease test.
- Indole, Methyl red, Voges-Proskauer, Citrate (IMViC) test (Indole, Methyl Red, Voges-Proskauer (MR-VP), and Simmons Citrate's agar slants were inoculated by stabbing the butt and streaking the slant).

The isolates producing a Red (alkaline) slant, a yellow (acid) butt, gas, and hydrogen sulfide production (H_2S) were considered positive on TSIA. Urease-negative, Methyl Red-positive, Voges-Proskauer-negative, Indole-negative, and Citrate-positive results were identified as Salmonella.[22]

Enumeration of Salmonella: For the enumeration of Salmonella, both the meat swab and environmental swab samples were mixed with 10 mL of BPW and incubated overnight at 37 °C. Then, 1 mL of the original sample was added to six serial test tubes, each containing 9 mL of BPW, for serial dilution.

To perform the dilution, 0.1 mL of the sample was taken from each of the diluted test tubes and added onto XLD agar plates. The plates were then incubated at 37 °C for 24 to 48-hours. After incubation, the growth of Salmonella colonies on the XLD agar surface was checked, and the colonies were statistically counted.

A colony counter was used to count the Salmonella colonies. The number of Salmonella per mL of the original undiluted sample was calculated after determining the dilution and dilution factor. The dilution (D) was calculated by dividing the volume of the sample by the sum of the total volume of the sample and the diluent. The dilution factor (DF) was calculated by dividing the sum of the total volume of the sample and the diluent by the volume of the sample.

We calculated the number of Salmonella per mL (cfu/mL) in the original undiluted sample by multiplying the counted number of colonies by the dilution factor.[23]

Data Management Analysis

The collected data was coded and entered into a Microsoft Excel 2007© spreadsheet. The analysis was performed using Statistical Package for Social Sciences (SPSS) version 20 software. Descriptive statistics were used to summarize the collected data. The prevalence of Salmonella was calculated using percentages.

To assess the associations between the occurrence of Salmonella in different samples, statistical tests such as the Chi-square (χ^2) test were conducted. The analysis was done at a 95% confidence interval (CI) and a 5% level of significance. A p-value less than or equal to 0.05 was considered statistically significant, indicating that there is a significant association between the variables being tested.

RESULTS

Prevalence of Salmonella

Out of a total of 224 samples examined from butcher houses in Chelenko town for the prevalence of Salmonella, 54 samples (24.1%) were found to be positive for Salmonella.

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Among the different sample sources examined at the butcher houses, the highest prevalence of Salmonella was observed in cutting board swab samples, with 5 samples (31.6%) testing positive. Afterward, we conducted swab tests on meat samples, and out of the 30 samples tested, 26.78% tested positive for Salmonella. Knife swab samples had 4 positive samples (22.2%), worker hand swab samples had 11 positive samples (19.6%), and hook swab samples had 3 positive samples (15.8%).

Statistical analysis showed that there was no significant variation between the different sample sources from butcher houses regarding the positivity of Salmonella (p=0.6660) (Table 1).

Table 1. *Prevalence of Salmonella from Butcher House at Chelenko Town*

Sample Source	No. Examined	No. Positive	Percentage (%)	χ^2 (p-Value)
Meat	112	30	26.78	
Cutting Board	19	6	31.6	
Knife	18	4	22.2	2.38(0.666)
Worker Hand	56	11	19.6	
Hook	19	3	15.8	
Total	224	54		

Load of Salmonella Detected

Among the different sample sources, the highest load of Salmonella was detected on the meat swab taken from the butcher house, with a count of 6.88×10^5 cfu/mL. This was followed by the cutting board with a count of 6.51×10^5 cfu/mL, the worker's hand with a count of 6.09×10^5 cfu/mL, the knife swab with a count of 4.59×10^5 cfu/mL, and the hook swab sample with a count of 3.28×10^5 cfu/mL.

Statistical analysis showed that there was no statistically significant difference between the sources of samples for the detected load of Salmonella (p=0.199) (Table 2).

Table 2. *The Average Load of Salmonella from Goat Meat Swabs and Environmental Swab Samples*

Sample Source	Average Load of Salmonella Cfu/mL	χ^2 (p-Value)
Meat	$6.88X10^5$	
Worker hand	$6.09X10^5$	
Cutting board	$6.51X10^5$	6(0.199)
Knife	$4.59X10^5$	
Hook	$3.28X10^5$	

Cfu/mL: Colony forming units per milliliters of sample

Questionnaire and Observation Survey

Socio-demographic characteristics of respondents: Among the 33 respondents from the 11 butcher houses interviewed for their socio-demographic characteristics, the distribution of educational status was as follows: 3 respondents (9%) were illiterate, 19 respondents (57.6%) had completed grades 1 to 8, 4 respondents (12.1%) had completed grades 9 to 12, and 7 respondents (21.2%) had education beyond grade 12.

In terms of gender, the majority of the respondents were male, with 21 respondents (63.6%), while 12 respondents (36.4%) were female.

Regarding the age group of the respondents, 8 respondents (24.2%) were between 11 and 24-years-old, 18 respondents (54.5%) were between 25 and 50-years-old, and 7 respondents (21.2%) were between 50 and 75-years-old.

The knowledge, attitude, and practices of butcher house workers: The study assessed the knowledge, attitude, and practices of butcher house workers regarding critical factors that could impact the safety and quality of goat meat.

Out of the 33 respondents, a majority of 24 (72.6%) had not received any formal training, while 9 (27.3%) had acquired informal training. However, all the respondents, 33 (100%), were aware that contamination poses a risk and can influence the quality and safety of goat meat. About half, 18 (54.5%) of the respondents, were aware of zoonotic diseases, while the others did not have knowledge about zoonosis (Table 3).

Regarding hygiene practices, out of the total respondents, 20 (60.6%) washed their hands only, 8 (24.2%) used detergents in addition to water, and 27 (81.8%) cleaned their shop and equipment every day at the end of their work. Among them, 6 (18.2%) washed their hands after work, 16 (48.5%) washed before work, 8 (24.2%) washed both before and after, and 3 (9%) of the respondents did not wash their hands at all while handling meat. Moreover, 14 (42.4%) wore different jewelry materials, and 22 (66.7%) underwent a medical examination before being interviewed. 25 (75.6%) of the respondents used their own working clothes, while the remaining 8 (24.2%) shared clothing when handling meat (Table 3).

Butchers Observational Survey

The observational survey of 11 butcher houses in Haramaya town revealed the following findings regarding their hygienic practices:

- 5 (45.5%) of the butcher houses were observed to use clean knives and cutting boards, while the majority, 6 (54.5%), were not using clean utensils.
- 8 (72.7%) of the butchers were not wearing clean clothing, while the remaining 3 (27.3%) were observed to wear clean clothing.
- Only 2 (18.2%) of the butchers used aprons (protective clothes), while the majority, 9 (81.2%), did not use any protective clothing.
- Among the butchers, 7 (63.6%) were observed to handle money with bare hands, which can pose a contamination risk.
- Additionally, 10 (90.9%) of the butchers were using a single knife and cutting board for different types of meats and offal, which can also lead to cross-contamination.

DISCUSSION

Proper meat handling practices are crucial to ensuring the quality

Table 3. *The Knowledge, Attitude, and Practices of Butcher House Workers*

Factors	Values	Frequency	Percentage (%)
Received training	Yes	9	27.3
	No	24	72.7
Know contamination as risk	Yes	33	100
	No	-	-
Know about zoonosis disease	Yes	18	54.5
	No	15	45.4
Take medical examination before	Yes	22	66.7
	No	11	33.3
Dirty cloth and utensils cause of harm	Yes	30	90.9
	No	3	9
Jewellery materials	Worn	14	42.4
	Not worn	19	57.6
Hand washing	After work	6	18.2
	Before work	16	48.5
	Before and after	8	24.2
	Not washed	3	9
Manner of washing hands	Rinsing with water only	20	60.6
	Using detegents and water	8	24.2
	Not washed hand	5	15.2
Keeping clean is easy for you	Yes	5	15.2
	No	28	84.8
Smoking/chewing while working	Yes	12	36.4
	No	21	63.4
Cleaning equipment's and butcher house	Every day at end of work	27	81.8
	Before starting work	6	18.2
Wear working clothes	Individually	25	75.6
	Commonly	8	24.2

and safety of meat. Knowledge of hygienic meat handling practices throughout the process of goat meat production, processing, and distribution is essential in formulating preventive measures to reduce the risk of foodborne diseases associated with meat consumption.[24] The current study found that males are more likely to be involved in goat meat processing than females, which is consistent with a report from Eguale[25] in central Ethiopia. The mean age of the respondents in this study was 43-years, ranging from 11 to 75, which is lower than the mean age of 46.5±6.5 reported in another study Garedew et al[26] but higher than the mean age of 27.5±8.5 mentioned in a different study Esmaeili et al[6]. This suggests that older food handlers may have better hygienic practices compared to their younger counterparts.

In the current study, it was found that more than 57% of the butcher house workers had only completed primary school education. Similarly, over 70% of the butchers did not receive job-related training in food hygiene and instead acquired their skills through informal observations. These findings are consistent with a previous report by Weldo et al[19] which also noted a prevalence of primary school education and a lack of job-related training among butcher house workers in Dire Dawa City, Ethiopia. Due to their limited knowledge of hygiene, sanitation, the risks of contamination, and personal hygiene practices, these employees may inadvertently cross-contaminate and mishandle meat in an unhygienic manner. It is crucial for food handlers, including butchers, to possess the necessary knowledge and abilities to handle food hygienically. Proper training is essential, providing them with the fundamental concepts and requirements of personal hygiene.[27]

Moreover, Salmonella particles from goat meat and contact with dirty equipment during the slaughter of backyard animals could have contaminated the aprons. Workers may have used their hands to handle the meat, unconsciously transferring Salmonella to their aprons in the process. This study indicates that carcasses and related samples in butcher houses were contaminated with Salmonella, putting consumers at risk of contracting Salmonellosis from consuming the meat.

In the present study, it was found that more than 72% of butcher house workers did not receive job-related training but instead acquired their respective skills through observation. These results are in agreement with the report Garedew et al[26] which stated that most of the butcher house workers in Mekelle City, Ethiopia, had only received primary school education and lacked job-related training. As a result, these workers could unknowingly cross-contaminate meat and fail to handle it hygienically due to a lack of knowledge regarding hygiene, sanitation, and the risk of contamination. Their personal hygiene practices might also be inadequate.

Although most of the butcher house workers believed that unclean hands and equipment were major causes of meat contamination and posed health risks to meat consumers. The study found that some workers still carelessly contaminated the products by using unclean cutting boards and knives while working.

The hygiene standards in the butcher houses are poor. A significant portion of butchers (63.6%) handle money with their bare hands while processing the meat, neglecting the use of proper protective clothing. This finding is lower than a study Weldo et al[19] that reported 93.3% of butchers in Dire Dawa City handling money while processing meat. Handling food with bare hands can lead to cross-contamination and introduce harmful microorganisms into otherwise safe food, as highlighted by another study.[28] Therefore, it is crucial to take all feasible precautions to limit or eliminate this contamination, given that meat handlers are likely sources of microbial contamination.[29]

Moreover, paper money can be a source of various infections, including Salmonella, as it is frequently exchanged between different people. Handling carcasses with bare hands after touching such contaminated objects can lead to cross-contamination. Another concern is that the majority of butchers use a single knife for all types of edible offal and meat, and they also use a single cutting board without cleaning or sterilizing any of these items. Such general butchering practices encourage the contamination of goat meat.[30]

It is evident that these unhygienic practices in the butcher houses can pose significant risks to both the butchers themselves and the consumers. Proper training and the implementation of hygiene protocols are essential to ensuring the safety of the meat and preventing the spread of foodborne illnesses.

The study examined the knowledge, attitude, and hygiene practices of butchers in relation to critical factors that could impact the safety and quality of goat meat. Among the 33 respondents, 24 (72.6%) had not received any formal training, while 9 (27.3%) had acquired their skills through informal means. Approximately 54.5% (18 respondents) were aware of zoonotic diseases, while the remaining respondents had no knowledge about them. A significant majority, 90.9% (30 respondents), knew that wearing dirty clothes or having dirt on cloth and utensils could cause harm. However, 84.8% (28 respondents) stated that maintaining a clean environment was challenging for them.

Regarding hygiene practices, the study found that 81.8% of butcher workers cleaned their butcher area and equipment every day after sales and washed their hands with water only after work. However, more than 84% of participants expressed difficulty in maintaining clean and hygienic practices. Additionally, over half of the respondents admitted to smoking or chewing gum while at work.

In the present study, we found that 66.7% of butcher house workers had undergone job-related medical tests, which agrees with a study conducted by Igbinosa[31].

The overall prevalence of Salmonella was found to be 20.5%. Out of 224 goat meat and environmental swab samples examined, the prevalence of Salmonella was 20.08%, 31.6%, 22.2%, 19.6% and 15.8% for goat meat swabs, cutting board swabs, knife swabs, hand swabs, and hook swabs, respectively. These results were consistent with a report by Weldo et al[19] which found a Salmonella prevalence of 17.7% in goat carcass swabs in Dire Dawa. The study highlights a high occurrence of Salmonella in raw goat meat sold in the butcher houses, indicating a significant level of contamination in the town. The presence of Salmonella in the raw goat meat suggests poor hygienic practices during the processing stage by the goat meat handlers. Lack of utensil sterilization and failure to maintain clean working surfaces might have led to contamination, as Alemu et al[32] reported.

The current study's finding of a 20.5% prevalence of Salmonella in goat meat is lower than a study in Nigeria,[15] which reported a prevalence of 24.2% in goat meat. However, it is higher than the 60% prevalence reported in Tanzania.[19] Additionally, the prevalence of Salmonella determined in this study is higher than in other Ethiopian studies,[27,31,33-35] where the prevalence ranged from 3.33-11.7% in goat carcass swabs. This variation could be attributed to differences in the hygienic and sanitary procedures used. Moreover, the lack of training on hygiene and sanitation for butcher house workers and their inadequate knowledge about hygienic meat processing contribute to the high contamination of carcasses. In Ethiopia, where many people prefer raw or undercooked meat,[32] Salmonella contamination in carcasses poses specific public health implications.

Regarding environmental samples, the prevalence of Salmonella was 31.6%, 19.6%, 22.2% and 15.8% for cutting board swabs, hand swab samples, knife swabs, and hook swab samples, respectively. The high prevalence of Salmonella from cutting board swabs suggests significant contamination, possibly due to the use of a single cutting board for carcasses and offal by over half of the butcher houses. Poor handling of carcasses, hygiene issues among personnel, and contamination during handling and cutting board washing might also add to the contamination problem, echoing's[35] findings, even though hook swab samples showed less prevalence.

The study also measured the average loads of Salmonella on different samples. The results revealed that the highest average viable count of Salmonella was obtained from meat swab samples taken from butcher houses (6.88×10^5 cfu/mL), followed by cutting board swab samples (6.51×10^5 cfu/mL), while the lowest average load of Salmonella was found in hook swab samples. In comparison, the findings of the current study are higher than the 9.1×10^2 cfu/g to 1.07×10^4 cfu/g viable count of Salmonella reported from goat meat in Uyo Metropolis, Akwa Ibom State, Nigeria.[23] This variation may be attributed to various hygienic and sanitary practices. The study found no appreciable difference in the load of Salmonella between the backyard and butcher house environmental samples, indicating that all sampled areas were contaminated due to inadequate hygienic practices by the goat meat handlers during the processing stage.

CONCLUSION

The current study discovered a high load and prevalence of Salmo-

nella in goat meat, pointing to inadequate hygienic standards and improper meat handling procedures in the butcher shops. Cutting boards, hooks, knives, and staff hands in these establishments were probably where the contamination first started. As a result, if these problems are not resolved, goat meat that is sold to consumers could end up being a major source of Salmonellosis.

RECOMMENDATIONS

Based on the above conclusions, the following recommendations were made:

- **Training programs:** Implement training programs to educate goat meat handlers about best practices in handling, personnel hygiene, and processing meat. Increasing awareness among butcher workers and the wider community about zoonotic diseases transmitted through consuming uninspected goat meat is crucial.
- **Sanitation and hygiene:** Enforce strict sanitation and hygienic practices in all sampled areas to reduce bacterial loads and minimize the risk of contamination.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

The College of Veterinary Medicine's Veterinary Public Health Department at Haramaya University, Ethiopia, approved the current research protocol. Ethical clearance was waived due to the minimal involvement of humans and animal subjects, ensuring compliance with ethical considerations.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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