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Evaluation of bacteriological profile of meat contact surfaces, handling practices of raw meat and its associated factors in butcher shops of Arba Minch town, southern Ethiopia-A facility based cross sectional study

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Abstract

Background Meat is subjected to contamination from a range of sources throughout animal slaughter and its sale. The demand for meat products in Ethiopia has been increased dramatically; especially the consumption of fresh chilled meat becomes a status of symbol.

Objectives This study aimed to evaluate the bacteriological profile of meat contact surfaces, raw meat handling practices, and its associated factors in butcher shops located in Arba Minch town, southern Ethiopia.

Methods and Materials A facility-based cross-sectional study was carried out among meat handlers in butcher shops in Arba Minch town from November to December 2020. A pre-tested and semi-structured interviewer-administered questionnaire was used to collect the data on workers meat handling practices and the sterile swab was used to collect samples from selected meat contact surfaces for bacteriological analysis. Statistical Package for Social Sciences (SPSS) version 21 was used for data analysis. Binary logistic regression analysis was utilized to assess the presence and degree of association between raw meat handling practice and independent variables. Adjusted odds ratio with a 95% confidence interval at *P*-value < 0.05 was considered statistically significant.

Result and Conclusion This study revealed the knowledge and handling practice gap among meat handlers of butcher shops. Knowledge of food handling hygiene has shown significant association with handling practice [AOR = 4.5 (1.182,17.202)]. The median total viable count of bacterial loads from the swab samples of butchers' hands, knives, and the tables was 5.60 ± 0.80, 5.60 ± 1.00, 5.70 ± 1.00 log10 Colony-forming unit (CFU)/cm^2, respectively. Escherichia coli was the predominant isolate 34(68%) followed by Staphylococcus species 28(56%) and Salmonella species 19(38%). The median total bacterial load obtained from the samples exceeds the acceptable value of less than 5.0 log10 CFU/cm^2 on fresh meat. This indicates the need for improvement in the meat handling and processing chain to safeguard the public health against the risks of foodborne bacterial infections.

Keywords Bacteriological profile, Butcher shops, Meat, Handling practice

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Introduction

Meat consumption in developing countries has been continuously increasing from a modest average annual per capita consumption of 10 kg in the 1960s to 26 kg in 2000, and will reach 37 kg around the year 2030 (Heinz and Hautzinger (2007)). In developing countries, the sociocultural background plays a crucial role in determining food consumption patterns (SemenehSeleshi and Mooha (2014)). Meat products and stews, mainly from chicken, beef, lamb, and mutton are frequently consumed and prepared accordingly on holidays and social ceremonies in Ethiopia (GetuKebede (2010)). The widespread habit of raw beef consumption in Ethiopia is a potential cause of foodborne illnesses (Abayneh et al. (2014)). Because in Ethiopia, the safety of meat processing is still a public health concern (Gutema et al. (2021)). In most parts of the country, the animals are slaughtered locally in open areas without any hygienic prerequisites and raw meat is available in open-air local retail shops without appropriate temperature control and sold for consumption. This increases the chance of the meat being contaminated with pathogenic microbes (Gutema et al. 2021)). As a result, the habit of eating raw beef can create a favorable condition for the transmission of pathogens from contaminated meat to raw beef consumers (Centre for diseases control and prevention (CDC). Foods That Can Cause Food Poisoning. Retrieved from: https://www.cdc.gov/foodsafety/foods-linked-illness. (2021)).

Fresh meat contains an abundance of all nutrients required for the growth of bacteria, due to this, it is highly prone to microbial contamination regardless of its nutritional value (Tafesse et al. (2010)). Contamination of meat occurs from a range of sources throughout animal slaughter and its sale (Sofos et al. (1999) ; Lonergan et al. (2019)). Microbial contamination during slaughter, dressing, and cutting involves the transfer of microorganisms from the exterior of the animal mainly from its hide and/or interior of the animal represented by its intestinal tract (Bhandare et al. (Bhandare et al.2009)). The environment of the slaughterhouse, the floor of the retail outlet, the air in the outlet, working equipment, and the vehicle used for the transportation of the meat act as the external sources of contamination (Sofos et al. (1999) ; Bhandare et al. (2009)).

In spite of the increased consumer demand for food safety standards for raw meat, there are still poor hygiene and sanitary practices along the food production chain which contribute to the unacceptable levels of microbial load in meat (Mtenga et al. , (2000)). According to Food and Agricultural Organization (FAO), total viable plate count numbers exceeding 100,000 CFU/cm^2(> 5.0log10CFU/cm^2) and Enterobacteriaceae counts of more than 1000 CFU/cm^2(> 3.0log10CFU/cm^2) on fresh meat are not acceptable and signal the alarm for meat hygiene to be urgently improved along the slaughter and meat handling chain (FAO (2007)).

According to World Health Organization (WHO), up to 30% of the population in developed countries suffer from foodborne diseases, whereas nearly 2 million deaths due to foodborne diseases are estimated in developing countries per year (WHO (2007)). A recent report by WHO on the estimates of the global burden of foodborne diseases highlight that, more than 600 million cases of foodborne illnesses and 420,000 deaths could occur in a year (WHO (2015)).

In Ethiopia, because of the limited scope of studies and lack of coordinated epidemiological surveillance systems, there is no data reporting the incidence of meat or food-borne outbreaks (Abayneh et al. (2014)). Though, a few studies conducted in Ethiopia have reported the public health importance of various bacterial pathogens associated with foods of animal origin, country-wide data regarding meat or food-borne diseases in Ethiopia are extremely scarce (Bayleyegn et al. (2003); Ejeta et al. (2004); Adem et al. (2008); Kumar et al. (2009); Tefera et al. (2009)).

In developing countries like Ethiopia, food-borne diseases occur because of the prevailing poor food handling and sanitation practices, inadequate food safety laws, weak regulatory systems, lack of financial resources to invest in safer equipment, and lack of education for food handlers (WHO (2004)). Food regulatory systems in Ethiopia are shared activities of various regulatory bodies such as the ministry of health, the ministry of agriculture, and rural development, and the quality and standard Authority of Ethiopia. However, the responsibilities and mandates given to these regulatory bodies are not adequately defined and demarcated Food et al. n. d.. Good personal hygiene and sanitary handling practices at work are essential parts of any prevention program for food safety. The inappropriate handling of foods by the food service industry has been implicated in 97% of food poisoning cases (Greig et al. (2007); Howes et al. (1996)).

To the best of our knowledge, there is no data on meat handling practices and the bacteriological profile of meat contact surfaces in the current study setting. This could hinder the government and stakeholders from taking appropriate measures to prevent the risk of meat contamination and its sequela on public health. Therefore, this study aimed to evaluate the bacteriological profile of meat contact surfaces, handling practices of raw meat, and identifying factors affecting meat handling practices that compromise the safety of meat supplied to the consumers of Arba Minch town in Ethiopia. The findings of this study would provide valuable information for

concerned bodies working to improve food safety and ensure the quality of meat supplied to consumers.

Methods and materials

Study design and setting

A facility-based cross-sectional study was conducted in Arba Minch town from November to December 2020. Arba Minch town is one of the largest and most highly populated towns in the Gamo zone, southern Ethiopia. The town has 4 sub-cities with a total of 11 smallest administrative units called kebeles. In this town, the number of commercial food establishments including butcher shops has been visibly increasing. Thence, there are about 30 hotels, 123 restaurants, and 53 butcher shops including butcheries in hotels and restaurants in the four sub-cities of the town.

Source and study population

The source population for this study was the personnel from all butcher shops and the equipment used in Arba Minch town butcheries, whereas the study population was selected butcher shop workers and equipment in Arba Minch town of Ethiopia.

Inclusion and exclusion criteria

Meat handlers who were actively working in the selected butcher shop during the study period were included. Meat handlers who were seriously ill and unable to communicate during data collection time were excluded from the study.

Sample size determination and sampling procedure

The single population proportion formula was utilized to determine the sample size using the assumptions that the proportion of raw meat handling practices $p = 50\%$ among butchers in the study area, 95% confidence interval (CI), and 5% margin of error (d). Since the source population in the study area was less than 10,000, sample size adjustment was considered, and by assuming a 10% non-response rate the total sample size used was 50. Regarding the sampling procedure, first, a simple random sampling method was used to select butcher shops located in Arba Minch town. Similarly, the lottery method was applied to select one worker among those who were predominantly or directly involved in handling raw meat at each selected butcher shop.

Data and sample collection methods

A pre-tested and semi-structured interviewer-administered KOBO collect survey tool was used to collect data. The data collection tool was developed using related published research articles (AyehuGashe and Haile (2014); Mekonnen Haileselassie, Habtamu Taddele, Kelali Adhana, Shewit Kalayou (2013); Gurmu and Gebretinsae (2013); Birhanu et al. (2017); Ntanga et al. (2014); Abd-Elaleem et al. (2014)). The questionnaire consists of questions addressing sociodemographic characteristics, training on meat handling hygiene, knowledge on meat handling hygiene, and raw meat handling practices. Nineteen questions were asked to assess the worker's meat handling practice and for each correct answer, one point was scored. Likewise, eight questions were used to assess the respondent's knowledge of meat handling hygiene, and for each correct response, one point was scored. The hygiene and sanitation of the butchers and butcher shops were assessed by direct observation using a checklist. The checklist consists of items to check whether the butchers wear appropriate overcoat, hair cover, keep fingernails short and clean, presence of skin rash, and others. Also, the butcher shop layout, general sanitation, presence of a refrigerator, and the way of meat placing in the shop were directly observed using the checklist.

Regarding sample collection for bacteriological analysis, swab samples from workers' hands and equipment such as knives and cutting tables of butcher shops were collected aseptically using sterile moistened cotton swabs. An area of $50cm^2$ was used for swabbing and the swabbed sample was soaked into the test tube with 10 ml buffered peptone water. The test tubes containing swab samples were labeled and transported with an icebox within two hours to the microbiological laboratory which is located in Arba Minch University College of Medicine and Health Sciences and the samples were processed within 24 h of arrival at the laboratory.

For administering the questionnaire and performing observation, three data collectors with public health backgrounds were recruited. The sample collection was carried out by three trained laboratory technicians. The entire data collection process was closely supervised by the investigators.

Bacteriological analysis of swab samples

For the purpose of isolation and identification of bacterial species, swab samples from meat contact surfaces of butcher shops were cultured on nutrient agar and blood agar (general media), macConkey agar, mannitol salt agar, and brilliant green agar as differential and selective media (ISO, TS (2009)). The spread plate method was used for sample inoculation (Atlas et al. (1995)), whereas incubation of Petri dishes containing samples was done at an appropriate temperature of 37 °C for 24-48 h duration (Ercolini et al. (2009)). Colony morphology on the plates was observed and colony sub-culturing was done to obtain pure colonies for biochemical testing. Well-isolated colonies were carefully examined microscopically for bacterial characteristics such as shape and color.

Gram staining, as well as an appropriate biochemical test such as lysine, Triple Sugar-Iron, catalase, motility, indole production, and citrate utilization, were performed following the standard protocol (Oyeleke and Magna (2008)). The isolates were identified by comparing their morphological and biochemical characteristics with standard reference organisms of known taxa, as described by Bergy's manual for determinative bacteriology (Vos et al. (2009)).

For determination of the total viable count, first serial dilutions were prepared from 1 ml of the sample and 9 ml of tryptone water (APHA (1992)). Then after, 0.1 ml of each dilution was surface plated onto a previously prepared plate count agar and distributed onto the entire surface of the medium using a plastic spreader. Then the plates were incubated for 24-48 h at 37 °C. Following incubation, the colonies of bacteria grown on plate count agar were counted using a colony counting chamber. Those plates showed a colony count between 30 and 300 CFU were considered as statistically reliable and accurate for microbial load counting (Eby (2021)). The number of distinct colonies on each plate was counted as Colony-forming unit (CFU) per ml of sample volume and was calculated by using the dilution factor of its concentration and converted to log10 CFU/cm^2 values. Mean values of total viable counts in log10 CFU/cm^2 of replicates were determined and reported as mean standard deviation (Swanson et al. (1992)).

Data quality control, processing and analysis

The quality of data was assured by proper designing and pre-testing of the data collection tools. The questionnaire was prepared in English, translated to Amharic, and then translated back to English to check for consistency. KOBO collect survey tool was used to collect data. The training was given to data collectors for two days on the objective, importance of the study, confidentiality of information, respondent's rights, techniques of interview, observation, and pre-test. Also, the data collectors have received training on how to use KOBO collect survey tool (i.e., how to open and close the tool, how to record the data, and how to save and send data to the server). A Pre-test was conducted in the nearby district to ensure the validity and reliability of the survey tools and the necessary feedback was presented to data collectors. Bacteriological tests were carried out by trained experts according to the standard operational protocol. All the media used for bacteriological laboratory tests were checked for expiration date and prepared and sterilized according to their respective manufacturer's instructions. The supervisors and principal investigator supervised the data collection process to ensure the completeness and reliability of the gathered data throughout the data collection process.

The bacteriological findings from swab samples and questionnaire data were checked for completeness, cleaned, and edited. Complete items were coded and entered into a Microsoft Excel spreadsheet and SPSS version 21 for analysis. Descriptive statistics like frequency and percentage were used to summarize the participant's socio-demographic characteristics, knowledge of food handling hygiene, and meat handling practice. Shapiro-Wilks statistical test was used to check for the normality of microbial counts converted into log CFU/cm^2. A binary logistic regression analysis model was applied to assess the presence and degree of association between butchers' meat handling practice and independent variables. The model fitness was checked by Hosmer and Lemeshow model fitness test. Those variables that showed association in bivariable logistic regression and had a p-value < 0.3 were exported to the multivariable logistic regression model to identify significant factors. Adjusted odds ratio with a 95% confidence interval, at P-value < 0.05 was considered statistically significant.

Operational definition

Practices

To assess the level of practice, those respondents who scored below or equal to the mean value for practice assessing questions were considered as having poor practice and those who scored above the mean value were considered as having good practice of meat handling.

Knowledge

To assess the level of knowledge, those respondents who scored below or equal to the mean value for knowledge assessing questions were considered as having poor knowledge and those who scored above the mean value were considered as having good knowledge of meat handling hygiene.

Results

Individual characteristics of the study participants

The data were collected from 50 butcher shop workers with a full response rate. Out of the total participants, 46(92%) are male, 36(72%) are married and 41(82%) are orthodox religion followers. Regarding respondents' educational status, about 37(74%) attended primary school. The minimum and maximum age of the respondents was 20 and 45 years with a mean age of 29 years. Regarding respondents' working experience, the minimum and maximum experiences were 1 and 20 years with a mean of 6 years. The majority of the participants responded that they have conducted medical checkups before employment and about 19(38%) of respondents

conduct medical checkups twice a year after employment. Regarding workers' exposure to training, only 17(34%) responded that they attended training on meat handling hygiene (Table 1).

Study participants knowledge on meat handling hygiene

Regarding butcher shop workers' knowledge of meat handling hygiene, the majority of the participants responded that microorganisms can cause meat spoilage as shown in Table 2 below. Regarding overall knowledge of meat handling hygiene, of the total participants, only 19(38%) responded above the cut-off mean score for knowledge assessing questions and had good knowledge of meat handling hygiene.

Meat handling practice of workers in butcher shops

More than half of the workers did not wear hair covers and protective coats while processing meat as shown in Table 3 below. Regarding overall workers' practice of meat handling, from the total participants, only 14(28%) responded above the cut-off mean score for practice assessing questions and had good practice of meat handling.

Table 1 Individual characteristics of the study participants in butcher shops of Arba Minch town ($n = 50$)

Variable	Frequency (N)	Percentage (%)
Sex		
Male	46	92
Female	4	8
Age		
20–29	31	62
30–39	13	26
40–49	6	12
Marital status		
Single	14	28
Married	36	72
Educational status		
Illiterate	5	10
Grade 1–8	37	74
Grade 9–12	8	16
Religion		
Orthodox	41	82
Protestant	9	18
Work experiences		
< 5 years	16	32
5–10 years	29	58
> 10 years	5	10
Have medical certificate		
Yes	42	84
No	8	16
Conducted medical checkup prior to employment		
Yes	35	70
No	15	30
Frequency of medical checkup after employment		
Annually	18	36
Twice a year	19	38
Every 3 month	13	26
Attended training on meat handling hygiene		
Yes	17	34
No	33	66

Table 2 Study participants knowledge on meat handling hygiene in Arba Minch town ($n=50$)

Variables	Frequency	Percentage (%)
Microorganisms can cause meat spoilage		
No	9	18
Yes	28	56
Not sure	13	26
Environmental contamination of meat is highly risky for meat shelf life		
No	3	6
Yes	42	84
Not sure	5	10
Food handlers with unhygienic practice could be the source for meat contamination		
No	0	0
Yes	50	100
Not sure	0	0
Chilling meat below two degree celsius helps retard meat spoilage		
No	6	12
Yes	37	74
Not sure	7	14
Touching offals then meat with bare hands cause meat contamination		
No	7	14
Yes	37	74
Not sure	6	12
Meat contamination can cause severe diseases		
No	7	14
Yes	39	78
Not sure	4	8
Apparently healthy food handlers might carry microorganisms		
No	13	26
Yes	30	60
Not sure	7	14
Handling meat when having diarrhea is risky for meat contamination		
No	20	40
Yes	28	56
Not sure	2	4

Factors associated with participant's meat handling practice

In order to identify determinants of meat handling practice, a binary logistic regression model was applied. In a bivariable logistic regression analysis, factors such as religion, work experience, having a medical certificate, attending training, and knowledge of food handling hygiene have been shown to have an effect (p-value < 0.3) and were exported to multivariable logistic regression for further analysis. In multivariable analysis, only knowledge of food handling hygiene has shown a significant association with meat handling practice ($p=0.02$). The odds of having good meat handling practice are four times more likely among those with good knowledge of food handling hygiene than the counterparts with AOR = 4.5 (1.182,17.202) (Table 4).

Results of observational survey

The sanitary level of the butcher shops and meat handlers was observed using checklist and presented in Table 5 below.

Results of bacteriological analysis of the samples

A total of 150 swab samples collected from 50 workers' hands, 50 knives, and 50 tables of different butcher shops were analyzed to isolate and identify the bacterial species. The bacterial species of meat contact surface samples identified in this study were *Escherichia coli, Staphylococcus spp., Salmonella spp., Shigella spp., Enterobacter, and Klebsiella spp*. *Escherichia coli* was the predominant isolate 34(68%) from meat contact surface samples, followed by *Staphylococcus spp.* 28(56%) and *Salmonella spp.* 19(38%) (Fig. 1).

Table 3 Meat handling practice of workers in Butcher shops of Arba Minch town ($n=50$)

Variables	Frequency	Percentage (%)
Do you wash your hands before handling meat?		
Yes	50	100
No	0	0
How do you clean your hands?		
With cold water and soap	49	98
With hot water and soap	1	2
Do you clean your butchery?		
Yes	50	100
No	0	0
How often do you clean your butchery?		
Hourly	2	4
Daily	44	88
Weekly	4	8
What type of meat cutting board do you use?		
Wooden	46	92
Plastic	4	8
Metallic	0	0
How do you clean your meat cutting board?		
With cold water and soap	40	80
Wiping with a piece of cloth	10	20
How often do you clean meat cutting board?		
Daily	40	80
Immediately after use	10	20
Do you clean meat weighing scale before using it?		
Yes	50	100
No	0	0
How do you clean your meat weighing scale?		
With cold water and soap	42	84
Wiping with a piece of cloth	8	16
Do you clean meat cutting knives before use?		
Yes	50	100
No	0	0
How do you clean knives before cutting meat?		
With cold water and soap	34	68
With hot water and soap	16	32
How often do you clean knives?		
Daily	50	100
Immediately after use	0	0
Do you wear gloves when handling meat?		
Yes	6	12
No	44	88
Do you wear head cover while selling meat?		
Yes	24	48
No	26	52
Do you wear protective coat while selling meat?		
Yes	21	42
No	29	58
Do you handle meat when you have lesion on your hand?		
Yes	11	22

Table 3 (continued)

Variables	Frequency	Percentage (%)
No	39	78
Do you handle meat when you have diarrhea?		
Yes	2	4
No	48	96
Do you keep finger nails long?		
Yes	35	70
No	15	30
Do you handle money/mobile phone while cutting meat?		
Not at all	29	58
Seldom	21	42

Table 4 Factors associated with meat handling practice of the study participants in Arba Minch town ($n=50$)

Variable	Category	Practice of meat handling		COR (95% CI)	*P*-value	AOR (95% CI)	*P*-value
		Poor N (%)	Good N (%)				
Sex	Female	3(6)	1(2)	1	0.88		
	Male	33(66)	13(26)	1.18(0.112,12.422			
Age(years)	20–29	23(46)	8(16)	1	0.56		
	30–39	8(16)	5(10)	1.79(0.453,7.120)			
	40–49	5(10)	1(2)	0.57(0.058,5.694)			
Marital status	Single	9(18)	5(10	1	0.45		
	Married	27(54)	9(18)	0.60(0.159,2.265)			
Religion	Orthodox	28(56)	13(26)	1	**0.23**	1	0.08
	Protestant	8(16)	1(2)	0.26(0.030,2.389)		0.09(0.006,1.378)	
Educational status	Illiterate	4(8)	1(2)	1	0.50		
	Grade1-8	25(50)	12(24)	1.92(0,193,19.091)			
	Grade9-12	7(14)	1(2)	0.57(0.028,11.849)			
Work experience	< 5 years	14(28)	2(4)	1	**0.20**	1	0.1
	5–10 years	18(36)	11(22)	4.27(0.813,22.513)		6.80(0.887,52.73)	
	≥ 10 years	4(8)	1(2)	1.75(0.124,24.650)		2.33((0.113,48.40)	
Have medical certificate	No	4(8)	4(8)	1	**0.14**	1	0.2
	Yes	32(64)	10(20	0.31(0.066,1.483)		0.34(0.64,1.79)	
Presence of health personnel supervision	No	4(8)	3(6)	1	0.35		
	Yes	32(64)	11(22)	0.45(0.88,2.378)			
Received training on food handling hygiene	No	26(52)	7(14)	1	**0.14**	1	0.3
	Yes	10(20)	7(14)	2.60(0.725,9.319)		2.5(0.415,15.641)	
Knowledge of meat handling hygiene	Poor	26(52)	5(10)	1	**0.02**	1	**0.02***
	Good	10(20)	9(18)	4.68(1.258,17.417)		4.5(1.182,17.202)	

* Significant association; *AOR* Adjusted odds ration; *COR* Crude odds ratio; *CI* Confidence interval

In this study, the median total viable counts for samples taken from butchers' hands, knives, and tables were calculated. For the decision of appropriate measures of central tendency and dispersion, the Shapiro-Wilks test was applied. This test resulted in a p-value of less than 0.05. Hence, the microbial counts were not normally distributed, median and interquartile ranges were used to summarize the data. The study revealed that the median total viable count was 5.60 ± 0.80, 5.60 ± 1.00, and 5.70 ± 1.00 log10 CFU/cm^2 for samples taken from the butchers' hands, knives, and tables, respectively.

Discussion

Despite the fact that training of food handlers on basic principles and requirements of personal and food hygiene plays a key role in ensuring the delivery of safe food products to the consumers (Adams et al. (2015)), in this study only 17(34%) of participants attended training on meat handling hygiene. This finding is in agreement

Table 5 Observational survey of Butcher shops in Arba Minch town, southern Ethiopian ($n = 50$)

Variables	Frequency (N)	Percentage (%)
Did the butcher wear appropriate over coat?		
No	18	36
Yes	32	64
Did the butcher wear appropriated hair cover?		
No	40	80
Yes	10	20
Butcher fingernails were short and clean?		
No	3	6
Yes	47	94
Discharge from butcher nose, ear, eye and cough observed?		
Observed	0	0
Not observed	50	100
Any visible skin rash, boils and wound observed?		
Observed	0	0
Not observed	50	100
How was meat placed in the shop?		
Hanged open air	43	86
Hanged within screen	7	14
Is there a refrigerator in the shop?		
No	42	84
Yes	8	16
General sanitation of the shop:/ventilation, wall, floor & cornice cleanness/		
Good	27	54
Poor	23	46
Did the butcher handle money while cutting meat?		
No	27	54
Yes	23	46
Did the butcher wear jewelry/ring on his hand?		
No	35	70
Yes	15	30
Did the butcher handle mobile phone while cutting meat?		
No	40	80
Yes	10	20
Can the location of the toilet can cause any kind of contamination?		
No	49	98
Yes	1	2

with the report of studies carried out in Mekelle, northern Ethiopia (Mekonnen Haileselassie, Habtamu Taddele, Kelali Adhana, Shewit Kalayou (2013); Gurmu and Gebretinsae (2013)). It is also in line with the finding of a study that took place in Gondar, which revealed that 66% of the respondents did not take training on food hygiene (Birhanu et al. (2017)). To this end, Bhandar et al. supported that most of the meat cutters in abattoir and butcher shops in developing countries are untrained and thus they do not give attention to the hygienic meat handling practice, and as a result, contribute immensely to bacterial contaminations (Bhandare et al. (2009)).

This study revealed that about 44(88%), 26(52%), and 29(58%) workers did not wear gloves, hair cover, and protective coat while processing meat, respectively. This finding is in agreement with the findings of the studies done in Mekelle, Ethiopia (Mekonnen Haileselassie, Habtamu Taddele, Kelali Adhana, Shewit Kalayou (2013); Gurmu and Gebretinsae (2013)). This finding is also comparable with the findings of a study done in Tanzania, in

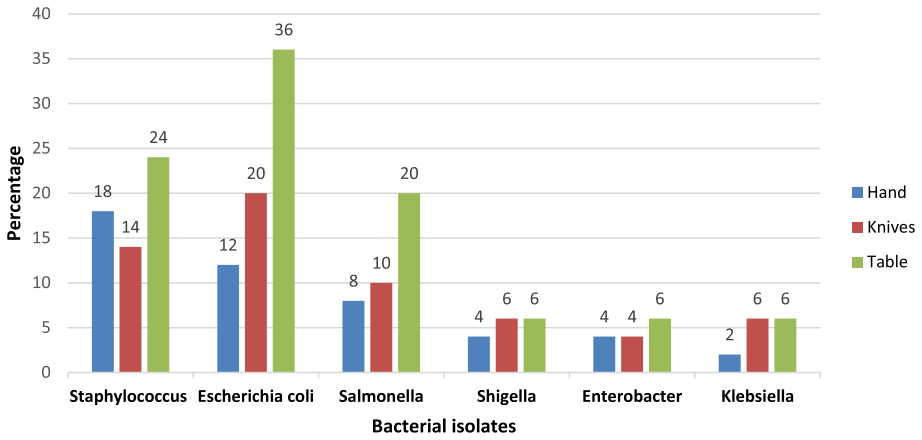

Fig. 1 Bacterial species identified from samples of meat contact surfaces in butcher shops of Arba Minch town ($n = 50$)

which 62.5% of the butchery workers did not wear protective cloth while selling meat (Ntanga et al. (2014)). Another related study in Alexandria, Egypt reported that only 30% of butchers wore protective aprons, and 16% wore gumboots and gloves which is also comparable with our finding (Abd-Elaleem et al. (2014)).

It is important that all possible measures including safe water supply, proper handwashing and sanitizing, keeping personal hygiene, cleaning meat processing equipment, and educating food handlers on safe food handling should be considered to reduce meat or food cross-contamination (Australian Meat Industry Council (2012); WHO (2005)). The importance of hand hygiene in the control of infection cannot be underestimated. Proper handwashing is a simple and effective way to minimize cross-contamination (Food and Drug Administration (2010)). Employee health and personal hygiene handbook. (2010)). In the current study almost, all workers wash their hands with cold water and soap before handling meat and after visiting the toilet. This situation is a little better than that described in Egypt which showed that 80% of the workers wash their hands before processing meat and of them, 37.5% used water and soap (Abd-Elaleem et al. (2014)). The current finding is also better than the report of a study done in Uganda, which revealed that only 11% of workers washed their hands before touching meat Mirembe n. d..

An observational survey of the current study indicated that 46% of the workers handled paper money while cutting meat. This finding is nearly in absolute agreement with the finding of the study conducted in Gondar which showed that 45.3% of the respondents were handling money while serving customers and the study done in Mekelle reported that 47.9% of the butchery operators handled money while handling meat as well (Mekonnen Haileselassie, Habtamu Taddele, Kelali Adhana, Shewit Kalayou (2013); Birhanu et al. (2017)). On the other hand, our finding is better than the report of a wok from another study in Mekelle which showed that 91.7% of workers handled money while handling meat (Gurmu and Gebretinsae (Greig et al.2007)). Moreover, a study done in India revealed that 98% of the butcher's handled money by themselves simultaneously during cutting and processing the meat, which depicts that our finding is better than the latter Tuneer and Madhavi (2015).

The aforementioned variation is probably due to differences in the food hygiene knowledge of workers in the study settings. Paper money is widely exchanged for goods and services in most countries worldwide. It is exchanged many times in circulation and provides a large surface area as a breeding ground for pathogens (Gadsby (1998)). The person handling money should not be allowed to handle food during retailing or serving.

In the present study, knowledge of food handling hygiene has shown a significant association with meat handling practices. This finding is consistent with studies conducted in Turkey and Ethiopia (Nigusse and Kumie (2012); Baş et al. (2006); Kibret and Abera (2012)). According to FAO, food handlers should have basic knowledge of food hygiene to practice safe food handling (FAO (1997)).

Meat is rich in nutrients required for the growth and multiplication of microorganisms; this makes meat the most perishable food item (Tafesse et al. (2010); Magnus (1981)). The median count of bacterial load from butchers' hands in this study is lower than the findings of the studies conducted in Mekelle and Gondar, which was 6.15 log10 CFU/cm^2 and 6.96 log10 CFU/cm^2, respectively (Gurmu and Gebretinsae (Greig et al.2007); Birhanu et al. (2017)). This finding is again

slightly lower than the microbial distribution obtained in Mumbai, India which was 5.85 ± 0.16 log10 CFU/cm^2 (Bhandare et al. (2009)).

Related studies conducted in the northern part of Ethiopia have reported 7.8 log10 CFU/cm^2 (Birhanu et al. (2017)), 6.89 log10 CFU/cm^2 (Gurmu and Gebretinsae (2007)) mean count of bacterial load from butcher's knives, which were higher than the values obtained in the current study. However, the current result is nearly in line with the report of the study conducted in India which was 5.52 ± 0.03 log10 CFU/cm^2 (Bhandare et al. (2009)).

The total median bacterial load obtained from the processing tables in this study was higher than the value reported by the study done in Ibadan, Nigeria (Fasanmi et al. (2010)), which was 5.54 log10 CFU/cm^2 but it was lower than the report of studies conducted in Northern Ethiopia (Gurmu and Gebretinsae (2007); Birhanu et al. (2017)). In the present work, all swab samples from butchers' hands, knives, and tables of the butcher shops in Arba Minch town of Ethiopia were collected during the winter (November–December) season.

The difference in the median viable count of bacterial load among studies might be attributed to the variations in the manner and season of sample collection and the numbers of the collected sample and the same might be the case for this study (Li et al. (2004)). The presence of a high microbial load on the butcher's hands, knives and meat processing tables might be an indication of the ineffectiveness of the method used in handwashing and cleaning the processing equipment. The median total viable count obtained from butchers' hands, knives, and tables in the current study is above the acceptable average total viable count value given by FAO (2007)).

Swab samples collected from butcher's hands, tables, and cutting knives showed a remarkable diversity of bacterial species. This may be due to the contribution of multiple sources of contamination such as unsanitary practices performed in the butcher shops, butchers' ignorance, poor personal hygiene, and utilization of contaminated materials (Elisel et al. (1997)).

The bacterial species isolated from samples of the meat contact surface in the current study were predominantly *Escherichia coli* followed by *Staphylococci spp.* and *Salmonella spp*. This finding is in line with the report of other related studies carried out in the Mekelle and Gondar towns of northern Ethiopia (Gurmu and Gebretinsae (2007); Birhanu et al. (2017)). In Gondar, out of 53 isolates, *E. coli* was the predominant isolate 20 (37.74%), followed by *Staphylococcus spp.* 13 (24.53%) and *Salmonella spp.* 11 (20.75%). Similarly, in Mekelle, out of 25 isolates, *Escherichia coli* was the predominant isolate 8 (32%) followed by *Staphylococcus spp.* 5 (28%). This finding is also in agreement with the work from Tanzania, which identified *E. coli, Staphylococcus spp.*, and *Salmonella spp.* isolates from samples collected from abattoirs and meat shops (Ahmad et al. (2013)). The present finding is also in agreement with the reports of studies done in Nigeria where they isolated almost similar organisms from meat, seafood, and other ready-to-eat foodstuffs (Ukut et al. (2010); Okonko et al. (2009)). The presence of diverse bacterial species is an indication of the deplorable state of poor hygienic and sanitary practices at the butcher shops.

Strengths and limitations of the study

This study is the first study in assessing bacteriological profile and meat handling practice in butcher shops in the current study setting. The data would have paramount importance to the regulatory bodies to control the quality of meat supplied to the consumers. In this study, the swab samples for bacteriological analysis were collected once on the spot during the data collection period. Due to this, the present study is unable to compare the bacteriological findings of the sample before and after processing.

Conclusion and recommendations

This study disclosed the presence of a gap in meat handling practice in the chain of meat processing in butcher shops. The median bacterial load from butchers' hands, knives, and tables in the current study exceeds the acceptable value of less than 5.0 log10 CFU/cm^2 on meat. In this study, the isolation of various bacterial species from meat contact surfaces underlines the existence of a poor level of equipment hygiene as well personnel hygiene and poor sanitation at the butcher shops. Therefore, to safeguard the public against the risk of food-borne infections of animal origin, provision of effective training for meat handlers regarding food safety, basic principles and requirements of personal hygiene, sanitation, and meat handling hygiene would play a crucial role. The regulatory bodies should make close and regular supervision of establishments to ensure good handling practices and quality management in the chain of meat processing.

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Authors' contributions

TK has contributed to the conception and design of the study, conducted the study, recorded, analyzed, and interpreted the data, and drafted the manuscript; MS was involved in the conception of the study, checking the collected data, analysis, and drafting the manuscript. MA was involved in the data curation, statistical analysis, interpretation and drafting the manuscript. All authors read the draft manuscript, improved, and approved the final manuscript.

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Availability of data and materials
The data used to support the findings of this study are available within the paper.

Declarations

Ethics approval and consent to participate
Ethical approval and clearance were obtained from the Institutional Ethical Review Board of Arba Minch University, College of Medicine and Health Sciences with reference number (IRB/501/13) and support letter was obtained from Arba Minch town health office. Written consent was obtained from owners/managers and workers of the butcher shops after assuring the aim of the study, data collection procedure, confidentiality issue of the obtained information, the right of participants, the risk and benefit of participating in this research work. All participants were randomly selected without any discrimination.

Consent for publication
Not applicable.

Competing interests
The authors have no conflict of interest in this work.

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