The Slaughtering and Dressing Procedures of Livestock Inside the Butcher Shops Generate High Levels of Bacterial Contamination

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Abstract: *Background and Objective*: Raw meats from animal carcasses are most frequently contaminated with bacteria during the slaughtering and dressing process. Therefore, this study aimed to determine the bacterial quality of raw meat from lamb, goat and beef carcasses immediately after slaughtering at butcher shops in Al-Mafraq city-Jordan.

Materials and Methods: A total of 243 meat samples were aseptically cut from the hand, leg and back of carcasses at three butcher locations, designated as site-C (the central part of the city), site-N (the north side of the city) and site-S (the south side of the city). Samples were processed and then cultured on nutrient agar and xylose lysine deoxycholate (XLD) agar plates aerobically at 35 °C for 48 h for enumeration of bacteria and total *Enterobacteriaceae* count (TEC) by aerobic plate count (APC). APC and TEC were expressed as colony forming units per gram of meat (CFU/g).

Results: APC and TEC in the raw meats ranged from 11.6-28.1 X 10^6 CFU/g on nutrient agar and from 23-120 X 10^3 CFU/g on XLD agar medium. By meat type, the lamb had the highest APC and TEC, followed by beef. By location, the highest APC and TEC were shown in the C-Site, followed by the S-Site. There were significant differences between APC counts by location and meat type ($P<0.05$). APC and TEC at the legs of the tested carcasses were significantly higher than the hand and back regions ($P < 0.05$).

Conclusion: There were high levels of bacterial loads on raw meat carcasses during slaughtering and dressing process inside the butcher shops. The bacterial load exceeded the guideline set up by international studies and was influenced by location, meat type and part of the carcass. To improve the quality of locally produced raw meat, these findings emphasized the need to curb slaughtering animal inside the butcher shops.

Keywords: Aerobic plate count, carcasses, contamination, hygiene conditions, selective medium.

INTRODUCTION

Globally, the production and consumption of raw red meats continue to grow as a consequence of rising income levels [1]. Raw red meats remain an important source of essential macro- and micronutrients, including but not limited to protein, phosphorus, selenium, zinc, iron as well as a good source of niacin, vitamin B6, vitamin B12 and riboflavin [2,3]. In addition, meat is a highly perishable food due to relatively high water and nutrient content [3]. These conditions provide a good and favorable environment for the growth of the food borne pathogens including bacteria.

Generally speaking, consumers prefer eating meat from freshly slaughtered and younger animals. In addition, some consumers prefer to eat certain raw meat or undercooked food. This was clearly noticed in Kibbeh nayeh, which is a beloved Lebanese dish made with raw lamb, goat or beef meat. However, there is a greater concern and awareness of bacterial contamination of fresh raw meats. For instance, bacterial contamination of fresh raw meat may occur during the slaughtering and dressing operations as well as due to poor hygienic conditions of post-slaughter practice [5-12]. Meat contamination can also result from the horrific conditions under which the slaughtered animals were reared as well as the conditions of transportation to slaughtering premises or abattoirs [10,13,14]. Hence, it is likely that these contaminated meats may contain disease-causing bacteria.

A variety of disease-causing bacteria have been isolated and identified in meat samples, including *E. coli*, *Klebsiella*, *Enterobacter*, *Serratia*, *Citrobacter*, *Salmonella* and *Shigella*, *Yersinia pestis*, and others [15,16,17]. These bacterial species are important members of *Enterobacteriaceae* family [9,15,18]. This family has at least 210 species in up to 53 genera that are gram-negative, rod-shaped, non spore-forming, fermenting sugar to produce acid, and facultative anaerobes. They are widely distributed in food, soil, vegetation, and water as well as in the intestine of human and animals, but more importantly, they are common in the feces of animals and human [8,16]. Furthermore, some species of *Enterobacteriaceae* are found to be responsible for causing several types of enteric diseases and food borne illness in human and animals [8,16,19]. For instance, food-borne illnesses such as tuberculosis, acute gastroenteritis, enterocolitis salmonellosis, shigellosis, listeriosis, leptospirosis, brucellosis and others infectious diseases are usually

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caused by consumption of meat or food contaminated with bacteria in most parts of the world [20-22]. Every year, it has been estimated that millions of food-borne illness cases occur in most parts of the developed and developing countries, costing billions of dollars in medical care and lost productivity [19-24]. Collectively, the issues of meat safety and quality are the most important issues in marketing and has raised serious concern in the medical community and in the nation at large. These issues highlight the importance of implementation of proper sanitary slaughtering and dressing procedures to minimize the contamination of fresh raw meats.

It is a fact that the safety and food quality rely on knowing the levels of microorganisms in those food items. In addition, the presence of high levels of *Coliforms* and *E. coli* in the food sample is widely used as an indicator of poor food quality, fecal pollution and poor sanitation during food processing [25,26]. Therefore, to ensure and determine the safety and quality of many food items such as meat, it is very important to estimate the total number of microorganisms in a given food sample [8,27,28]. Various techniques or methods have been established to enumerate the total number of microbes, the total *Enterobacteriaceae* count (TEC), coliform count and/or *E. coli* count in any given food sample. One of the these methods of enumeration is the total viable plate count (VPC) or aerobic plate count (APC) [25-28]. This method is a good indicator of overall bacterial populations on food sample.

Lamb, goat and beef raw red meats are the most consumed meats in the Middle East particularly in Jordan and other Arab countries. Here in Jordan, the authority has ordered all farmers to slaughter their livestock in abattoirs. They also require that all abattoirs must have a full-time meat inspector to inspect all live animals before slaughtering and all carcasses for diseases after slaughtering and before they send them to butcher shops. However, some butchers disobey the rules of slaughtering the animals in abattoirs by slaughtering their animals inside butcher shops or at the door-step of the butcher shops, or next to their shops. They prefer to do this to avoid paying the costs of the slaughtering their animals inside the abattoirs to abattoir official. This illegal slaughtering practice prevents the official inspector from examining the slaughtered animals. Hence, our major concern was that there was no way to inspect carcass meats and ensure that meats from these animals were free from diseases.

According to the report of the Ministry of agriculture in Jordan in 2009, Al-Mafraq governorate is considered one of the major markets of red meat in Jordan with a total number of cattle exceeding 615,000 [29]. The value of cattle in Jordan was estimated at over 240 million JD, and around 15.7 thousand tons of meats from lamb, 6.1 thousand tons of meats from goat and 5.8 thousand tons of meats from beef are produced. In recent years, there was a noticeable increase in sale and consumptions of cattle meats in Al-Mafraq governorate. More importantly, it was seen that there is an increasing tendency by butchers in Al-Mafraq governorate to slaughter their animals inside the butcher shops. This illegal practice can lead to a broad range of adverse health effects including increasing the risks of susceptibility to food born diseases. Also, it has the potential to threaten the surrounding natural environment and can magnify the risk of environmental hazards not only from point of view of human public health but also for the disposal of wastes in a legal manner. Moreover, these shops lack the certified meat processing units, and the basic hygiene requirements in these butcher shops seemed to be much below the required standards and did not meet the minimum hygiene requirements by law. To the best of our knowledge, data on in bacterial load in cattle meats from butcher shops in Al-Mafraq governorate did not exist at all and/or they may be very limited. Because of these reasons mentioned above, an attempt was made to analyze the bacterial load in raw meat collected from freshly dressed lamb, goat and beef carcasses slaughtered in butcher shops in Al-Mafraq city. To evaluate the fresh raw meat quality and safety, all meat samples collected from the selected carcasses were quantified for the APC and TEC after carcasses final washing.

MATERIALS AND METHODS

Study Area

This work was carried out in the city of Al-Mafraq. It is the main city Al-Mafraq governorate. It is located in the northern part of the kingdom, at about 65 km north-east of Amman, the capital of Jordan kingdom. It is the only governorate in the kingdom that bordered by Iraq to the east, Syria to the north, and Saudi Arabia to the south. This governorate is the second largest governorate in the kingdom by area and the second smallest by population density. The climate from May to October is characterized by being hot and dry, whereas in January to March is cool and wet. The

average amount of rainfall per year in this governorate ranges from 150 to 250 mm.

The total population lives in this district was estimated to be about 309,000 individuals in 2013. This number does not include refugee people from Syria, which were estimated to be around 200,000 individuals. The local people live in Al-Mafraq district depend on animal husbandry and farming. These two brands of agriculture constitute the central element of the economy for Mafraq Governorate. Animals such as sheep, goats, and cows are usually raised for milk and meat productions.

Slaughter Procedure

The slaughtered animals were born from native species in Al-Mafraq city-Jordan. Some butchers raised their own animals for meat production in local small farms located at Al-Mafraq district. Other butchers usually purchase these animals directly from farms or from the animal market for slaughter. The average age of lamb and goats was usually between 10 to 12 months of age, whereas the average age of steers was around 18 months of age.

According to our observations, some butcher shops of Al-Mafraq city slaughtered their animals inside their premise (i.e. outside of a slaughterhouse or abattoir). Animals were usually transported to the butcher shops on the same morning of slaughter. These animals were usually transported by small pickup trucks or vans. Animals had to wait outside butcher shops for about one to two hours prior to slaughter.

For killing animals and initiation of the bleeding process, a sharp knife was mainly used to cut the animal's throat and to remove quickly as much blood as possible. Then, they allowed for the blood to drain in a small container or go down into municipal drains causing pollution. After most of the blood drain out, the dressing process was immediately carried out by butchers. Due to lack of means and proper tools, the dressing procedures of the carcasses were normally carried out on the floor. The processes of removing the skin (hide), hair, head, extremities, feet, tail, penis or udder and any loose fat in the abdominal cavity of carcasses were manually detached. This was followed by insertion of hooks in hind legs of carcasses and hung them vertically by both hind legs. After that, the internal cavity of the carcass was opened for removal of viscera and other internal organs. Finally, all carcasses were washed at the end of the dressing process.

Experimental Design

This study mainly focused on estimation of the bacterial load of carcasses that were illegally slaughtered and dressed for meat consumption inside the butcher shops. During this study, lamb, goat, beef meat carcasses were investigated from different registered butcher shops in Al-Mafraq city-Jordan. The registered butcher shops were randomly selected to represent three locations or zones in Al-Mafraq city, designated as C-Site (the central part of the city), N-Site (the north side of the city), S-Site (the south side of the city). Three different butcher shops from each location were randomly selected to collect the red meat samples.

During the entire period of this study, a total of 81 carcasses were sampled from the randomly selected butcher shops. Several visits were made to the butcher shops in the morning hours (between 6 to 8 am) and three carcasses per visit were analyzed. Three meat samples were randomly selected from the hand, leg and back parts of each carcass per visit. Thus, a total of 243 raw red meat specimens were collected from lamb, goat, and beef carcasses during the entire study.

Sample Collection for Microbiological Analysis

Immediately after the completion of dressing and final washing of carcasses, around 50 grams of raw red meat were excised with an ethanol-sterilized knife from hand, leg and back parts of each carcass and separately placed in sterile bags. Between each sample, knife was disinfected with ethanol. Gloves were utilized in the sampling procedure. To prevent cross-contamination, gloves were changed between samples and the meat samples were directly placed inside factory-sealed, pre-sterilized and disposable bags. The meat samples were handled only within the bag. After that, bags were labeled and placed on ice-box and delivered to the laboratory for processing, cultivation of bacteria and further analysis.

Growth Media

A 0.1% peptone salt solution was prepared and used as a diluent for dilutions of different meat samples. This solution is widely used as an isotonic diluent and is the best diluent for enumerating the microorganisms [9]. A solution of 0.1% of peptone was prepared by dissolving 9.50 grams of peptone in 1000 ml distilled water. The solution was then sterilized by autoclaving at 15 lbs pressure (121°C) for 15 minutes.

Nutrient agar (NA) was used for the cultivation of bacteria. NA is basically general purpose medium that supports the growth of a wide variety of non-fastidious bacteria as well as use to the enumeration of bacteria in meat samples. The NA media composed of peptone (5g/L), beef extract (3g/L), sodium chloride (5g/L) and agar (15g/L).

To enumerate of *Enterobacteriaceae* from meat samples, the xylose lysine deoxycholate (XLD) agar medium was used. The XLD medium contains the following components: xylose (3.75 g/L), lactose (7.5 g/L), sucrose (7.5 g/L), L-lysine (5 g/L), sodium deoxycholate (2.5g/L), sodium chloride (5g/L), sodium thiosulfate (6.8 g/L), yeast extract (3 g/L), ferric ammonium citrate (0.8 g/L), novobiocin (10 mg/mL), phenol red (0.08 g/L) and agar (12.5 g/L). The pH of all media was adjusted to 7.4.

Enumeration of Total Bacteria

Plating of samples and APC were carried out according to the established procedure [30]. The fresh raw meat sample was finely chopped using a sterile stainless steel knife. Then, the meat sample was transferred to a sterile 0.1% peptone salt solution as dilution medium (25 g + 225 ml; wt (g) meat: v (ml) 0.1% peptone salt solution). After that, the sample was homogenized in an electric blender at low speed for 2 minutes. The resulting homogenate was filtered through a sterile muslin cloth without pressure for removal of the particulate matter. After filtering the homogenate, three different serial dilutions ranging from 10^{-3} , 10^{-6} and 10^{-9} were prepared for each meat sample in normal saline. An aliquot of 0.1 ml of each diluted sample was then transferred aseptically to the surface of NA plate. Similarly, 0.1 ml of each diluted sample was also placed into XLD agar plate to count *Enterobacteriaceae*. All agar plates were gently swirled to uniformly distribute the sample and get all area covered using a sterile glass spreader.

All plates of NA and XLD were aerobically incubated for 48 hours at 35°C. After incubation, the resulting colony forming units (CFUs) were counted for each plate. The APC was determined using standard plate count agar (Difco Laboratories, Detroit, USA). The average number of APC per triplicate plates was then calculated as CFUs per gram meat (CFU/g). All samples were processed within four hours of collection. A triplicate of both NA and XLD plates were prepared and used for estimation of APC for each dilution.

Statistical Analyses

The data were presented as the means ± standard deviation (M±SD). A t-test or ANOVA was used to test if there was any significance in the mean values of APCs between meat samples by the location of butcher shops, meat type and parts of the slaughtered animal. Statistical analysis was performed by SPSS version 12.0 for Window. P values ≤ 0.05 were considered significant.

RESULTS

In this study, to examine the safety and quality of the lamb, goat and beef carcasses slaughtered and processed inside the butcher shops in the city of Al-Mafraq, a total of 243 raw meat samples from 28 lambs, 28 goats, and 25 beef carcasses were randomly selected for this purpose. Baseline characteristics of the study meat sample were tabulated in Table **1**. Meat samples were categorized by meat types into lamb, goat, and beef, by the location of the butcher shops into three locations (C-site, N-site, and S-site) and by meat parts from the hand, leg and back. The samples were assessed for bacterial load and the effects of these variables on meat quality were determined.

Table 1: Baseline Characteristics of the Study Meat Samples

Variable		N	(%)
Location of Butcher shop	C-Site	90	(37.0)
	N-Site	71	(29.2)
	S- Site	82	(33.8)
Meat type	Lamb	28	(34.6)
	Goat	28	(34.6)
	Beef	25	(30.8)
Meat parts	Hand	81	(33.3)
	Leg	81	(33.3)
	Back	81	(33.3)

Data are presented as number of meat samples (N) and percentage (%).

Plate count method was used to estimate APC. The average APC values (expressed as CFU/g) for lamb, goat and beef meat samples obtained from different butcher shops were listed in Table **2**. Meat samples were classified by the type of meats and location of butcher shops. In all selected butcher shops, quantitative analysis data revealed that the average APC levels for all tested meat samples ranged from 11.6 X 10^6 to 28.1 X 10^6 CFU/g when NA was used as

Table 2: Distribution of APC Values in Raw Meats from Lamb, Goat and Beef Carcasses Collected from Butcher Shops at Three Different Locations in Al-Mafraq City, Jordan

Type of Meat	APC (CFU x 10^6)			Average
	N-Site	S-Site	C-Site	
Lamb	16.8^a±6.3	21.6^b±1.6	28.1^c±2.4	22.1
Goat	14.0^a±5.3	17.7^b±4.3	24.2^c±2.6	18.6
Beef	11.6^a±7.4	20.3^b±4.0	26.3^c±2.1	19.4
Average	14.1	19.8	26.1	

Data were shown as M±SD. Results were reported as colony forming units per gram of meat (CFU/g). $^{A-C}$: Means with different superscript letters in the same raw were statistically significantly different (P<0.05). And means with same superscript letters in the same column indicated a statistically significant difference (P<0.05).

cultivation medium. With respect to the meat type, the highest APC level was seen in lamb (22.1 X 10^6 CFU/g), followed by beef (19.4 X 10^6 CFU/g) and goat (18.6 X 10^6 CFU/g). Statistical analysis revealed that significant differences were observed in APC values between the three types of raw meats (lamb, goat, and beef) (P<0.05). With respect to the location of butcher shops, the largest APC value was found in meat samples collected from C-Site (26.1 X 10^6 CFU/g), this was followed by S-Site (19.8 X 10^6 CFU/g) and N-site (14.1 X 10^6 CFU/g). The observed differences between these locations were statistically significant.

The average levels of TEC in meat samples of lamb, goat and beef carcasses taken from butcher shops at three different sites of the city of Al-Mafraq were reported in Table **3**. For the cultivation and enumeration of *Enterobacteriaceae,* XLD agar was used as a selective medium. It can be seen that the average TEC ranged from 23-120 X 10^3 CFU/g in XLD agar medium. With respect to the location, the highest TEC value was found in meat samples collected from C-Site (97 X 10^3 CFU/g), followed by S-Site (72 X 10^3 CFU/g) and lowest in N-Site (38 X 10^3 CFU/g) (P<0.05). With respect to the type of meat, the mean TEC value of lamb meat carcasses were higher than those seen in beef or goat carcasses (P< 0.05). Based on these data, significant differences were observed between the three types of meats as well as between the three examined locations.

To examine the possibility of variation in bacterial concentrations in different parts of the carcasses, meat samples were taken from three different body regions of each carcass, including hand, leg, and back. The average APC values in meat samples obtained from the hand, leg, and back of lamb, goat and beef carcasses were listed in Table **4**. The average APCs for all meat samples taken from the leg, hand, back regions of all carcasses ranged from 20.2-31.4 x 10^6 CFU/g, 7.7-27.6 x 10^6 CFU/g, 2.9- 24.5 x 10^6 CFU/g, respectively. A comparison between different meat types revealed that the highest significant APC level was found in the lamb, followed by beef, and the lowest was for goat (P<0.05). By part, the highest significant APC level was recorded for the leg, followed by hand, and the lowest was for the back (P<0.05). By site, the highest APC value was obtained in C-site, followed by S-site and N-site.

The average TEC levels in raw meat samples taken from the hand, leg and back parts of lamb, goat, and beef carcasses were presented in Table **5**. A comparison between three meat types of the tested carcasses showed that the highest significant TEC

Table 3: The Average TEC Values in Raw Meats from Lamb, Goat and Beef Carcasses Collected from Butcher Shops at Three Different Locations of the City of Al-Mafraq, Jordan

Type of Meat	TEC (CFU x 10^3)			Average
	N-Site	S-Site	C-Site	
Lamb	39^a±11	82^b±21	120^c±42	80
Goat	23^a±14	59^b±13	76^c±25	53
Beef	51^a±38	76^b±15	94^c±27	74
Average	38	72	97	

Data were shown as (M±SD). TEC: total *Enterobacteriaceae* count. Results were reported as colony forming units per gram of meat CFU/g: $^{A-C}$: Means with different superscript letters in the same raw were statistically significantly different (P<0.05). $^{A-C}$ Means with same superscript letters in the same column indicated a statistically significant difference (P<0.05).

Table 4: Distribution of APC Values in Raw Meats Collected from Hand, Leg and Back of Lamb, Goat and Beef Carcasses Sold in Butcher Shops at Three Different Locations in City of Al-Mafraq, Jordan

Meat		APC (CFU x 10^6)			Average
Type	Part	N-Site	S-Site	C-Site	
Lamb	Leg	22.8	26.2	31.4	26.8±4.3[a]
	Hand	16.9	21.7	27.6	22.1±5.4[a]
	Back	10.3	17.0	21.1	16.1±5.5[a]
Goat	Leg	21.1	22.5	29.4	24.3±4.4[b]
	Hand	8.3	20.9	24.2	17.8±8.4[b]
	Back	2.9	9.7	21.0	11.2±9.2[b]
Beef	Leg	20.2	27.3	29.5	25.7±4.9[c]
	Hand	7.7	22.4	26.9	19.0±10[c]
	Back	7.0	10.2	24.5	13.9±9.3[c]

The data were expressed as CFU/g (colony-forming units per gram raw red meat). [a-c] Means with same superscript letters indicated a statistically significant difference (P<0.05).

Table 5: The Average Value of TEC in Raw Meats from Hand, Leg, Back of Lamb, Goat, Beef Carcasses Obtained from Butcher Shops at Three Different Locations in City of Al-Mafraq, Jordan

Meat		TEC (CFU x 10^6)			Average
Type	Part	N-Site	S-Site	C-Site	
Lamb	Leg	54	98	141	98±43[a]
	Hand	26	78	123	76±48[a]
	Back	22	42	77	47±27[a]
Goat	Leg	41	93	121	85±40[b]
	Hand	18	58	90	55±36[b]
	Back	23	32	47	34±12[b]
Beef	Leg	88	117	134	113±23[c]
	Hand	45	83	87	71±23[c]
	Back	22	44	56	41±17[c]

The data were given as CFU x 10^3/g (colony-forming units per gram raw red meat). TEC: total *Enterobacteriaceae* count. [a-c] Means with same superscript letters indicated a statistically significant difference (P<0.05).

level was found in lamb, followed by beef and the lowest was for goat (P< 0.05). The average TEC level of meat samples collected from legs was significantly higher than those taken from hand and back parts of all carcasses (P< 0.05). By location, the highest significant number of TEC levels was found in the C-Site, followed by S-site and N-site (P< 0.05).

DISCUSSION

Recently, the process of animal slaughtering inside the butcher shops of Al-Mafraq governorate were rapidly increased. Therefore, 243 meat samples of lamb, goat and steer carcasses were collected from local butcher shops and average values of APC and TEC were estimated during this study. The results showed that the average numbers of APC of the raw meat samples ranged between 11.6 x10^6 and 28.1 x 10^6 CFU/g. Interestingly, the APC from our study were much higher than those reported by some previous studies [14,27,31-35]. The results of our study were in close agreement with that of Haileselassie and colleagues [34] who concluded that high level of bacterial load in raw meat collected from butcher shops is associated with use of backyard slaughter and the lack of food safety knowledge in meat handling techniques. Along the same lines, Bhandare *et al*. concluded that the APC of beef, lamb and goat meats from retail shops were significantly higher as compared to the abattoirs [14]. Low counts for all bacteria for swab samples taken from forequarter, back and hindquarter of carcasses were documented in one

abattoir in São Paulo, Brazil [36]. These finding were in agreement with our study indicating poor hygienic conditions and practices during slaughtering and dressing procedures inside the butcher shops in comparison with abattoir.

According to the International Commission on Microbiological Specifications for Foods (ICMSF, 1986), the APC of 10^6 CFU/g or above are unacceptable quality, values between 10^4–10^6 CFU/g are marginal quality and values ≤ 10^4 CFU/g are acceptable quality [37]. Based on the Raw Meat Grading and Marketing Rules, 60% of meat samples must be less than 10^6 CFU/g to be considered as acceptable for human consumption [38]. Based on our generated data, the average APCs in raw meat samples from the carcasses of lamb, goat and beef appeared to exceeded this guideline or the standard set up by these agencies.

Based on our findings, bacterial contaminations of meat carcasses were unfortunately very high and common during slaughtering and dressing processes inside the butcher shops. This study also suggested that bacterial load may be influenced by the location of butcher shops, type of meats and part of slaughtered animals (hand, leg and back). According to Oh and Lee, there were significant monthly and season differences in the APCs and the highest number of APCs occurred in the small butcher shops, and the APCs were significantly varied between different places as well as between different meat types [32]. These results were entirely consistent with our findings.

Globally, *Enterobacteriaceae* such as *Salmonella* and *Shigella* were found to be one of the most known food borne pathogens that are responsible for millions of cases of acute enteric infections and/or acute gastroenteritis every year [4,19,39-43]. Therefore, enumeration and identification of *Enterobacteriaceae* are important for surveillance, prevention and control of food-borne diseases. Based on our data, all examined samples of raw meat carcasses were tested positive for *Enterobacteriaceae* and the TEC ranged between 28 x 10^3 to 120 x 10^3 CFU/g of meat. These data indicated that the presence of high number of *Enterobacteriaceae* in meat samples from the selected butcher shops was alarming and generally could be a risk to human health, especially in the most congested regions with costumers. These findings clearly indicated that the assessment of microbial load in meat carcasses is deemed necessary, particularly in butcher shops.

There is no doubt that there are several possible explanations concerning the unexpected high bacterial load and the degree of variations in APC and ETC between various locations, the source of meats and the meat parts. A high bacterial load was observed in butcher shops due to the lack of proper infrastructure of dressing facilities and drainage, contamination of the facilities and equipments used during the slaughtering process as well as having more than two types of meats in butcher shop [27,31-32,34-35]. In support of these observations, poor sanitary conditions and hygiene practices were validated by eye observation during slaughtering and dressing of carcasses in all selected butcher shops. It is well documented that *Enterobacteriaceae* species can enter the meat through direct fecal-oral transmission from human or animal reservoir [19,43]. Thus, the major sources of *Enterobacteriaceae* were the skin, the oral and nasal cavity, and leakage of feces from digestive tract content of slaughtered animals during slaughtering and dressing of carcasses [5,9,14]. Moreover, the hands and clothes of personnel working in slaughtering rooms and excessive handling or touching of carcasses by too many people could contribute to elevated bacteria levels in food [6,44,45]. In addition, one possible explanation for high levels of *Enterobacteriaceae* in raw meats may due to high initial bacterial load in the animals before slaughtering process [7]. It is likely that all the suggested explanations were applicable to the present study and may explain the high levels of APC and ETC in the current study. Though this investigation included a small number of butcher shops, we are sure that, if extended to a wider range of butcher shops, the results would be the similar or confirm our findings.

CONCLUSION

The microbial indicators used in this study were APC and TEC. The results of present study revealed that all of raw meat carcasses of lamb, goat and beef carried markedly high initial bacterial numbers, and none of the tested samples within the acceptable limits according to the published guideline given by international standard or studies. In addition, the levels of APC and TEC appeared to be influenced by the location of butcher shops, type of meat and parts of the carcass from which the samples were taken. Therefore, this report can be deemed to be the first step to end such unauthorized slaughtering and dressing operations. Consequently, more monitoring and interventions are needed in order to improve the quality of meat to consumers and maximize the productivity of locally produced fresh raw meat in Jordan.

CONFLICT OF INTEREST

The Authors declare that there is no conflict of interest.

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