Received: 10 July 2022, Accepted: 16 August 2022

Journal of Advanced Veterinary Research
(2022) Volume 12, Issue 4, 386-391

Original Research

Microbial Profile of Imported Carcass under Chilled Storage

Esraa F. Hussein[1], Ali M. Ahmed[1*], Hanan A. Elghayaty[2], Heba M. Shaheen[1]

[1]Department of Food Hygiene, Faculty of Veterinary Medicine, Suez Canal University, Ismailia, Egypt.
[2]Department of Food Hygiene, Animal Health Research Institute Port-Said, A.R.C., Egypt.

***Correspondence**
Ali Meawad Ahmed
Department of Food Hygiene, Faculty of Veterinary Medicine, Suez Canal University, Ismailia, Egypt.
E-mail address: ameawad@yahoo.com

Abstract

Bacterial contamination has been proven to be common in a variety of foods, especially meats. For this reason, this study was conducted to evaluate the bacteriological quality of imported chilled meat traded in Port-Said markets where 64 random samples of chilled meats represented by 28 imported chilled beef meat samples from lots arrived at Port-Said port (un-marketed) and 36 imported chilled beef meat samples collected from retailed markets at Port-Said governorate (marketed). Samples were analyzed for their total aerobic count., *Enterobacteriaceae* count, *E. coli*, total *Staphylococcus*, and *S. aureus* counts and detection of *Salmonella*e. The total bacterial count recorded an average of 10.73×10^4 and 2.5×10^6 in un-marketed and marketed chilled meat respectively. The results showed that 18 out of 64 meat samples were positive for *Enterobacteriaceae* and 6 samples out of them were unaccepted for human consumption. The incidence of *E. coli* was in 6 samples from the examined chilled samples, and the 6 were unaccepted. For *Staphylococcus*, there were 24 positive samples, and 13 out of them were unaccepted and for *S. aureus*, 4 samples out of 64 samples were positive and 4 samples were unaccepted for consumption. Two samples out of 64 were positive for *Salmonella* and considered unfit for human consumption. The obtained results confirmed the poor bacteriological quality of some imported chilled meat that is marketed in Port-Said retailed markets which is related to unhygienic transportation methods until reach the retailed markets.

KEYWORDS
Enterobacteriaceae, carcasses, *E. coli*, meat, *S. aureus*, *Salmonella*

INTRODUCTION

Meat is a significant food source for humans, supplying many essential nutrients. Its demand is particularly high in developing countries (Juarez *et al*., 2021). Meat is considered a high-risk food due to its abundant nutrients that could favor the growth of microorganisms and the carriage of pathogenic microorganisms due to its high level of moisture, high percentage of nitrogenous compounds, good supply of minerals, glycogen, and its favorable pH which are an appropriate environment for different types of microbial growth (Bosilevac *et al*., 2019). Generally, a great diversity of microorganisms inhabits fresh meat, but different types may become dominant, which depends on many factors like pH, textures, composition, storage temperature, and transportation means of raw meat (Adu-Gyamfi *et al*., 2012).

Foodborne diseases are the major cause of mortality and infectious diseases, especially in developing countries. A variety of pathogenic microorganisms including bacteria, viruses, protozoans, and parasites are involved in several severe outbreaks worldwide (WHO, 2016). Most *E. coli*, *Staphylococcus* spp., and *Salmonella* spp. were found to be the cause of serious foodborne diseases (Bhandare *et al*., 2017). Sanitary conditions of the slaughterhouses, handling of meat, butcher shops, preservation, improper packing, selling process of meat, and the environmental conditions play great roles in the level of contamination (Bhandare *et al*., 2017). Meat tissues get contaminated during the various stages of slaughter, handling, transportation, and preservation. The risk of contamination happens from the point of entry of the animal into the slaughterhouse up to the time of meat consumption. In this regard, abattoir environments and slaughter processes play a leading role in the spreading of microbial contamination (Ali *et al*., 2010).

The commonest way for prolonging the shelf life of meat is by cooling. Two methods for preserving meat through low temperatures, namely chilling and freezing, can be applied. For chilling, meat is refrigerated at a temperature of 0°C to 4°C, and at -18°C for freezing. As the temperature becomes colder, the enzyme action, and the growth and development of bacteria become (Johanna, 2005). Both chilled and frozen imported types of meat are considered a significant source of bacteriological public health hazards and need special control attention (Hassanien *et al*., 2020).

Many studies have investigated the effect of chilled storage duration which pretended to be the critical factor in terms of maintaining meat quality and preventing spoilage for export pur-

ISSN: 2090-6277/2090-6269/

poses and other activities (Leygonie *et al*., 2012). Egypt imports different types of meat to fill the gaps in the requirements of animal protein (USDA, 2016). Whereas the maintenance of hygiene and sanitation is always questionable.

Total bacterial counts (TBC) and *Enterobacteriaceae* counts (EC) are good indicators of meat quality and its spoilage. Moreover, microbial quality of chilled meat obtained from markets can vary greatly, for these reasons, food products are being examined intensively for microbial contamination, especially during export/ import or marketing across boundaries. Therefore, this study was conducted to evaluate the bacteriological quality of imported chilled meat traded in Port-Said markets via determination of TBC, *Enterobacteriaceae* count, and detection of *Escherichia coli*, *S. aureus*, and *Salmonella*.

MATERIALS AND METHODS

Collection of samples

A total of 64 random samples (250 g weight of each) of imported chilled meats represented by 28 imported chilled beef samples from lots arrived at Port-said port (un-marketed) and 36 imported chilled beef samples collected from retailed markets at Port-said governorate (marketed), the recommended sampling sites were neck, brisket, rump, and flank cuts. All accrued samples have been subjected to bacteriological examination at Port-said analytical lab, Animal Health Research Institute, Egypt.

Preparation of samples

All samples were prepared according to the technique recommended by APHA (2001). Each sample was separately placed into clean sterile plastic bags and transferred in an insulted ice-box to the laboratory without delay under complete aseptic conditions. Flaming the surface of a 250 g sample from each site and removing it then cutting an area of 25 g from the area under the removed surface (70% ethanol flamed, between uses). The 25 g from each sample were transferred under aseptic condition to a sterile polyethylene bag containing 225 mL of 0.1% sterile buffered peptone water. The content of the bag was then homogenized using a stomacher (Lab. Blender 400, Seward Lab, London) to have a dilution of 10-1 then One ml of each diluent was used in the preparation of serial dilution and the rest was used as a pre-enrichment medium for isolation of *Salmonella*. The serial dilution was used in the determination of total aerobic counts (APHA, 2015), *Enterobacteriaceae* counts (ISO, 2017), total *Escherichia coli* (FDA, 2020) *Staphylococcus aureus* (ISO, 1999), and *Salmonella* (ISO, 2002a).

Statistical analysis

Data analysis was performed by using SPSS statistical software program (SPSS for Windows version 16, Spss Inc., USA). Data were expressed as mean ± standard error (SE). Two-way analysis of variance (ANOVA) with Duncan post-hoc multiple comparisons test. Any significant differences (P<0.05) were analyzed by the multiple comparisons' procedure of LSD (least significant difference), using a level of significance of alpha = 0.05.

RESULTS AND DISCUSSION

Meat is considered a rich nutrient matrix that provides a suitable environment for the proliferation of meat spoilage microorganisms and common foodborne pathogens.

From the results of this study, the total bacterial count (cfu/g) of un-marketed and marketed imported chilled meat examined at Port-Said lab in different meat cuts recorded an average from $10.73x10^4$ to $2.5x10^6$, respectively. When it was discussed, as recorded in Table 1, TBC showed a highly significant difference among different meat cuts; neck, brisket, flank, and rump in un-marketed imported chilled mat which recorded mean values of $3.6x10^3$, $2.6x10^3$, $3.8x10^5$ and $4.3x10^4$ respectively, these differences may be attributed to the location of each meat cut and handling practices, certain areas of the carcass are more likely to be contaminated or to remain contaminated than other parts. For these reasons, microorganisms are not uniformly distributed over the carcass (NAS, 1985). Also, high total bacterial counts (cfu/g) of marketed imported chilled meat at Port-Said markets in different meat cuts; neck, brisket, flank, and rump were noticed as $3.6x10^5$, $3.1x10^4$, $4x10^6$, and $5.5x10^6$ respectively. Hassanien *et al*. (2020) disagreed with the obtained results in aerobic plate count while Mansour and Basha (2009) nearly agree with the present study which was $3.4x10^4$ in frozen cuts also Saleh *et al*. (2013) revealed similar results when recorded $1.4x10^6$, $6.5x10^5$ in the fore quarter and $9.6x10^5$, $1.2x10^6$ in the hind quarter.

The prevalence of TBC in Table 3, revealed that 42.85% and 52.77% of un-marketed and marketed imported chilled meat respectively, contained microorganisms. However, the counts were

Table 1. Bacteriological quality results of imported chilled meat for different carcass sites

Sites	Total bacterial count Mean ±S.E.		Independent t-test	*Enterobacteriaceae* count Mean ±S.E.		Independent t-test
	Un-marketed (n=28)	Marketed (n=36)	p-value	Marketed (n=36)	Un-marketed (n=28)	p-value
Neck	$3.6x10^3$± 1.1 $x10^2$	$4.5x10^5$± 1.1 $x10^4$	<0.001***	2.6x10±1.1 x10	3.0x10±1.1 x10	0.394 ns
Brisket	$2.6x10^3$± 2.1 $x10^2$	$5.1x10^4$± 2.1 $x10^2$	0.967 ns	$3.1x10^3$±2.1 $x10^2$	$3.1x10^2$±2.1 x10	0.003**
Flank	$3.8x10^5$± 1.3 $x10^3$	$4x10^6$± 1.3 $x10^4$	0.018*	$4.3x10^3$±1.3 $x10^3$	$3.2x10^2$±1.3 $x10^2$	0.007**
Rump	$4.3x10^4$± 2.0 $x10^3$	$5.5x10^6$± 2.0 $x10^3$	<0.001***	$5.5x10^3$±2 $x10^3$	$3.5x10^3$±2 x10	<0.001***
Total	$10.73x10^4$± $6.6x10^4$	$2.5x10^6$± $10.8x10^5$	<0.001***	$3.29x10^3$± $4.99x10^2$	$1.04x10^3$ ± $3.4x10^2$	<0.001***
ANOVA	<0.001***	<0.001***		<0.001***	<0.001***	
Two-way ANOVA						
Corrected Model		<0.001***			<0.001***	
Group		<0.001***			<0.001***	
Sites		0.002**			<0.001***	
Group x Sites		0.004**			0.592 ns	

Table 2. Food-borne pathogens result from imported chilled meat at different carcass sites

Sites	Total *E. coli* count Mean ±S.E.		Independent t-test	*Staphylococcus aureus* count Mean ±S.E.		Independent t-test
	Un-marketed (n=28)	Marketed (n=36)	p-value	Un-marketed (n=28)	Marketed (n=36)	p-value
Neck	0.7x10±1.2 x10	< 10± 0 x10	0.420 ns	0.6x10±1 x 10	0.6x10^2±0.1 x10	<0.001***
Brisket	2.1x10^2±2.1 x10	3.1x10^3±2.1 x10^3	<0.001***	< 10± 0 x 10	0.3x10±0.1 x10	0.045 *
Flank	1.3x10^2±1.3 x10^2	4x10^2±1.3 x10^2	0.793 ns	0.4x10±1.3 x 10	< 10± 0 x10	0.940 ns
Rump	1.5x10^2±0.5 x10^2	5.5x10^3±2 x10^3	<0.001***	0.5x10±2 x10^2	2.1x10^2±0.2 x10^2	>0.05 ns
Total	1.40x10^2± 1.70x10^1	2.25x10^3± 4.52x10^2	<0.001***	0.63x10± 1.35x10	7.08x10 ± 1.93x10	0.008**
ANOVA	<0.001***	<0.001***		0.999 ns	<0.001***	
Two-way ANOVA						
Cor. Model	<0.001***			<0.001***		
Group	<0.001***			0.002**		
Sites	<0.001***			0.004**		
Group x Sites	<0.001***			0.001***		

Table 3. The prevalence of total bacterial count and *Enterobacteriaceae* in imported chilled meat for different carcass sites

Variable		Total bacterial counts Frequency (n, %)		Chi-square	*Enterobacteriaceae* Frequency (n, %)		Chi-square
		Un-marketed (n=28)	Marketed (n=36)	p-value	Un-marketed (n=28)	Marketed (n=36)	p-value
Record	Positive	12 (42.86%)	19 (52.78%)	0.803 ns	5 (17.86%)	13 (36.11%)	<0.001***
	Negative	16 (57.14%)	17 (47.22%)		23 (82.14%)	23 (63.89%)	
	MPL	106	106		102	102	
Acceptability	Accepted	25 (89.29%)	29 (80.56%)	<0.001***	27 (96.43%)	31 (86.11%)	<0.001***
	Unaccepted	3 (10.71%)	7 (19.44%)		1 (3.57%)	5 (13.89%)	

*, **, ***: Significant at p<0.05, <0.01, <0.001; NS: Nonsignificant at p>0.05. MPL = Maximum permissible limit according to ESS (3602/2013) for chilled meat.

considered satisfactory as these results were lower than those suggested by EEC (2005). Only 3 samples were unaccepted, based on the limit of TBC established by the (ESS) which is 10^6 cfu/g in chilled meat, from the un-marketed samples out of 28 which represents 10.7%, while there were 7 unaccepted samples out of 36 in marketed samples by 19.4%, the lowest results were recorded by Saleh *et al*. (2013), 4% and the highest were recorded by Zafar *et al*., (2016) in Karachi.

The high counts of total aerobic bacteria may be due to the homemade dressing of corpse hides at the hands of the abattoir workers. Generally, hygiene conditions are poor when foods are produced in non-industrial establishments, substantially because the necessary structure for technologically acceptable processes isn't available. Corruption or reduce keeping the life of stupefied meat can be generally attributed to the presence of a veritably large number of bacteria, these were substantially linked as members of psychotropic bacteria and certain other microorganisms able of growing at 0˚C.

For *Enterobacteriaceae*, it is evident from the results given in Table 1, which showed its mean values in un-marketed imported chilled meat samples were 3.0x10±1.1x10, 3.1x102±2.1x10, 3.2x10^2±1.3x10^2 and 3.5x102±2x10 (cfu/g) for neck, brisket, flank, and rump, respectively. Higher counts were recorded for total *Enterobacteriaceae* counts of marketed samples, where its mean values were 2.6x10±1.1x10, 3.1x10^3 ±2.1x10^2, 4.3x10^3±1.3x10^3, 5.5x10^3±2x10^3 (cfu/g) in the neck, brisket, flank, and rump respectively. Nearly similar results were recorded by Hassan and Soultan (2004); Stagnitta *et al*. (2006); Gwida *et al*. (2014) and Shaltout *et al*. (2016). While Zerabruk *et al*. (2019) found that *Enterobacteriaceae* is the dominant microflora of meat. Most of the *Enterobacteriaceae* present in meats come from fecal contaminations. Elevated numbers of *Enterobacteriaceae* can be used as an indicator for poor hygienic conditions during handling or inadequate storing of chilled meat and the bacterial contamination quality of chilled raw meats.

Table 2 reveals the *E. coli* counts in un-marketed and marketed imported chilled meat. Where the mean values were 0.7x10 ±1.2x10, 2.1x10^2±2.1x10, 1.3x10^2±1.3x10^2 and 1.5x10^2±0.5x10^2 in neck, brisket, flank, rump respectively in un-marketed samples. Higher *E. coli* count in marketed samples with mean values of <10±0 x10, 3.1x10^3±2.1x10^3, 4x10^2±1.3x10^2, and 5.5x103 ±2x103 in the neck, brisket, flank, and rump respectively.

Table 2 displays the Staph. aureus counts in the un-marketed imported chilled meat with mean values of 0.6x10 ±1x10, <10 ± 0x10, 0.4x10±1.3x10 and 0.5x10±2x10^2 in neck, brisket, flank and rump correspondingly. Those consequences have disagreed with the ones obtained by Abd El-Hady (2015), Abdaslam *et al*., (2014), El Jakee*et al*. (2014), and Tarabees *et al*. (2015) who isolated *S. aureus* from raw meat and meat products with higher incidence. The same table reveals the Staph aureus counts results from marketed chilled meat with a means of 0.6x10^2±0.1x10, 0.3x10±0.1x10, <10±0x10, and 2.1x10^2±0.2x10^2 in the neck, brisket, flank, and rump respectively, which are nearly similar to that obtained by Morshedy *et al*. (2013) who mentioned that the mean value of *S. aureus* was 4.3×102cfu/g. and to that obtained by Shaltoot *et al*. (2016) who found that the incidence of Staph. aureus was low with a mean value of 2.2 ± 0.07 log10, Attalla and Kassem (2011) recorded that the mean value of staph aureus count was 3.94 ±0.16 log10, and Azage and Kibret (2017) who found that the mean value of Staph. aureus was 3.88 log10 cfu/g for the examined samples. While higher results were obtained by El Kewaiky and Al Said (2015) who found that the mean value of *S. aureus* was 5.26±4.7 log10 in examined fresh samples and 4.4±3.88 log10 in frozen samples

Table 3, showed that only 1 sample was unaccepted for *Enterobacteriaceae* count, based on the limit of *Enterobacteriaceae* counts established by the ES (2005) which is 10^2 cfu/g chilled meat, from un-marketed samples out of 28 which represents 3.57%, while there were 5 unaccepted samples out of 36 in marketed chilled meat samples by 13.89%.

Considering the pathogenic parcels of *Enterobacteriaceae* and their high frequency in meat, strict observance of hygiene programs and systematical monitoring of *Enterobacteriaceae* at all stages of food products plays a pivotal part in icing food safety and controlling the transmission of pathogenic foodborne bacteria to humans.

Table 4 showed the acceptability of the examined chilled meat samples based on their *E. coli* count (n = 28, 36), where the percentage of the unaccepted samples were 7.14% and 11.11% in 28 un-marketed and 36 marketed imported *E. coli* chilled meat samples, respectively.

The same findings of *E. coli* incidence have been mentioned via Mansour and Basha (2009) who remoted *E. coli* from 8 % of the tested frozen meat and Ukut *et al*. (2010) who determined *E. coli* in 11.1% of samples that were gathered in Nigeria from two foremost markets. Meanwhile, a decreased result has been pronounced in Egypt through Elnawawi *et al*. (2012) who isolated *E. coli* O158 and *E. coli* O86 from samples of imported frozen meat, with a percent of 2.86% and 1.42%. In addition, different *E. coli* species were isolated from 5.71% of imported frozen meat. Additionally, Ahmed and Shimamoto (2013) in Egypt investigated the prevalence of some foodborne pathogens in meat samples gathered from slaughterhouses, butchers, street vendors, and retail markets, *E. coli* O157:H7 have been detected in 3.4%. The highest levels of *E. coli* were reported by Martinez *et al*. (2015) who found that *E. coli* is present in 97% of beef carcasses. High percentages of *Escherichia coli* are often used as hygiene indicators of foods of animal origin. Its presence in chilled meat may give a better indication than coliforms of inadequate treatment or post-process contamination from the environment and may help to indicate the extent of fecal contamination.

The presence of staphylococci is normally associated with human pores and skin and apparel, it additionally may be a result of unhygienic dealing with and processing using unclean knives, slicing boards, and garage ladders added to the terrible hygienic reputation of meals handlers in butchers' stores (Gebeyehu *et al*., 2013). *Staphylococcus aureus* is one of the most causative pathogens to developed foodborne illnesses causing an estimated quarter-million cases every year in the US. *S. aureus* is one of the most important food poisoning microorganisms (Naomi and Avraham, 2000) these pathogens are of major concern to the meat industries (Hannan *et al*., 2008; Morshdy *et al*., 2018).

Results given in Table 4 showed that the prevalence of *S. aureus* in the un-marketed samples was 3.57% and 8.33% for marketed samples. And for all the examined samples, there were 4 unaccepted samples out of 64 chilled meats (un-marketed and marketed). A nearly similar result was obtained by Iraha *et al*. (2011) who recorded the incidence of *Staph. aureus* was 1.3%, while a slightly higher incidence was obtained by Tassew *et al*., (2010) who found that the incidence of *S. aureus* was 12.1%.

On the other hand, a high incidence was achieved by Maarouf and Nassif (2008); Lamada *et al*. (2012) and Abdel Salam *et al*., (2014) who found that the incidence of *S. aureus* was 35.4% in the examined samples, Salek, (2000) who found that in 28 out of 61 samples the *S. aureus* incidence was 45.9%, also Gwida *et al*., (2014) who recorded incidence of *S. aureus* 48% and Tang *et al*., (2017) recorded 68% in Denmark. This difference in the prevalence of S aureus may be reflected in the sample sizes, sample types, hygienic measures, collection time, geographic locations, sanitary conditions of handlers, and the detection procedures used (Ge *et al*., 2017). According to the Egyptian standard specification ESS (3602/ 2013) for chilled meat, it has been proposed

Table 4. The prevalence of *E. coli* and *Staphylococcus aureus* in imported chilled meat for different carcass sites

Variable		*E. coli* Frequency (n, %)		Chi-square	*Staphylococcus aureus* Frequency (n, %)		Chi-square
		Un-marketed (n=28)	Marketed (n=36)	p-value	Un-marketed (n=28)	Marketed (n=36)	p-value
Record	Positive	2 (7.14%)	4 (11.11%)	<0.001***	1 (3.57%)	3 (8.33%)	<0.001***
	Negative	26 (92.86%)	32 (88.89%)		27 (96.43%)	33 (91.67%)	
	MPL	Free	Free		Free	Free	
Acceptability	Accepted	26 (92.86%)	32 (88.89%)	<0.001***	27 (96.43%)	33 (91.67%)	<0.001***
	Unaccepted	2 (7.14%)	4 (11.11%)		1 (3.57%)	3 (8.33%)	

*, **, ***: Significant at p<0.05, <0.01, <0.001; NS: Nonsignificant at p>0.05. MPL = Maximum permissible limit according to ESS (3602/2013) for chilled meat.

Table 5. The prevalence of *Salmonella* sp. in imported chilled meat for different carcass sites

Variable		*Salmonella sp.* Frequency (n, %)		Chi-square
		Un-marketed (n=28)	Marketed (n=36)	p-value
Record	Positive	0 (0.00%)	2 (5.56%)	<0.001***
	Negative	28 (100.00%)	34 (94.44%)	
	MPL	free	free	
Acceptability	Accepted	28 (100.00%)	34 (94.44%)	<0.001***
	Unaccepted	0 (0.00%)	2 (5.56%)	
	Unaccepted	0 (0.00%)	2 (5.56%)	

*Significant at p<0.05, ** significant at <0.01, *** significant at <0.001; NS, non-significant at p >0.05. MPL = Maximum permissible limit according to ESS (3602/2013) for chilled meat.

that chilled meat must be free from *S. aureus*.

The existing not succeed to detect *Salmonella* species from all examined un-marketed samples (Table 5), These results were agreed with those recorded by Elnawawi *et al*. (2012); Datta *et al*. (2012), Saleh *et al*. (2013) and Abdel-Raouf *et al*., (2014) also Abuelnaga *et al*., (2021) which failed to isolate *Salmonella* species from any of examined beef samples. While, disagreed with those given by Abdaslam *et al*. (2014); Maarouf and Nassif-Marionette (2008) and Ramadan (2015) who isolated *Salmonella* from beef and meat products.

On the other hand, *Salmonella* was detected in the marketed samples in 2 over 36 samples as 5.5% and the 2 samples were unaccepted (table 5), Nearly the same results were reported by Rhoades *et al*. (2009) for fresh meat samples detected *Salmonella* by in average 3.8% (0.0–7.5%) on raw beef samples. Higher results were detected by Ukut *et al*. (2010) who detected *Salmonella* spp. in 11.1% of the fresh meat in Nigeria. According to ESS (3602/2013) for chilled meat, all meat samples must be free from *E. coli* and *Salmonella* spp.

This study showed that there is a highly significant difference ($p<0.001$) between un-marketed and marketed chilled meat (marketed meat contained higher microbial content) and proved that raw retail chilled meats and meat shops are potential vehicles for transmitting meat-borne diseases, the findings of this study stress the need for increased consumer meat-safety education efforts.

CONCLUSION

In the light of the previously achieved results, it was concluded the poor bacteriological quality of some imported chilled meat that is marketed in Port-Said retailed markets which related to unhygienic transportation methods until reaches the retailed markets, refrigeration, and unsanitary handling during marketing and selling process of meat, which limits the opportunities of meat storage and commercial life and causes many foodborne diseases to human. Therefore, further studies should be carried out to establish the control measures that should be adapted to improve the bacteriological quality of imported chilled meat traded in markets to ensure meat safety.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Abd-El-Hady, M., 2015. Bacteriological and Molecular characterization of *Staphylococcus aureus* Isolated from Beef Meat Products in El Gharbia Governorate M.V.Sc., Cairo University, Egypt.

Abdaslam, S.A., Hassan, M.A., Kaheel, H.A., Abobaker, T.M., Alnourain, T.H., Hamdan, H.A., Gokul Shankar, S., Thambirajah, J., 2014. Isolation of *Escherichia coli* O157 and other foodborne pathogens from meat products and their susceptibility to different antimicrobial agents. Current Research in Microbiology and Biotechnology 2, 391-397.

Abdel-Raouf, M., Nabil, M. El-Sayed, M., 2014. Antimicrobial Activities of Some Herbs Extracts on Foodborne Bacteria. J. American Science 10, 76-85.

Abuelnaga, A.S.M., Abuelnaga, A.S., Abd El-Razik, K.A., Ata, N.S., 2021. Bacteriological assessment and multiplex-PCR test for the detection of meat adulteration of different animal species, Food Sci. Technol, Campinas, 41, 98-104.

Adu-Gyamfi, A., Torgby-Tetteh W., Appiah, V., 2012. Microbiological Quality of Chicken Sold in Accra and Determination of D10-Value of *E. coli*. Food Nutr. Sci. 3, 5, 693-698.

Ahmed, A.A. Shimamoto, T., 2013. Isolation and molecular characterization of *Salmonella enterica*, *Escherichia coli* O157:H7 and *Shigella* spp. from meat and dairy products in Egypt. International Journal of Food Microbiology 168–169, 57–62.

Ali, N.H., Farooqui, A., Khan, A., Khan, A.Y., Kazmi, S.U., 2010. Microbial contamination of raw meat and its environment in retail shops in Karachi, Pakistan. J. Infect. Develop. Countries. 4, 382-388.

APHA, 2001. American Public Health Association, Compendium of Methods for the Microbiological Examination of Foods. APHA Technical Committee on Microbiological Methods for Foods. Washington DC, USA.

APHA, 2015. Compendium of Methods for the Microbiological Examination of Foods. 4th Ed., APHA Technical Committee on Microbiological Methods for Foods. Washington DC, USA.

Attala, O. A., Kassem, G.M.A., 2011. Effect of good manufacturing practices (GMP) application on the bacteriological status of butcher s area in small scale meat processing plant. Global Veterinaria 7, 123-128.

Azage, M., Kibret, M., 2017. The Bacteriological Quality, Safety, and Antibiogram of *Salmonella* Isolates from Fresh Meat in Retail Shops of Bahir Dar City, Ethiopia. International Journal of Food Science. 2017, ID 4317202, 5 pages.

Bhandare, S.J., Aldridge, M., Capps, K., 2017. Validation method for detection of *E. coli* in the food. Food Control 11, 85-95.

Bosilevac, J.M., Zhilyaev, S., Wang, R., Luedtke, B.E., Wheeler, T.L., Koohmaraie, M., 2019. Prevalence and characterization of *Salmonella* present during veal harvest. Journal of Food Protection 82, 775–784.

Christensen, B., 1946. Urea decomposition as a means of differentiating Proteus and paracolon cultures from each other and from *Salmonella* and shigella types. Journal of Bacteriology 52, 461-466.

Cruickskank, R., Duguid, J.P., Marmion, B.P., Swain, R.H., 1975. Medical microbiology.12th Ed., Churchill, Livingston, Edinburgh, London and New York.

Datta, S.A., Akter, A., Shah, I.G., Fatema, K., Islam, T.H., Bandyopadhyay, A., Khan, Z.U.M., Biswas, D., 2012. Microbiological Quality Assessment of Raw Meat and Meat Products and Antibiotic Susceptibility of Isolated *Staphylococcus aureus*. J. Agric. Food Anal. Bacteriol. 2, 187-195.

EEC (Commission Regulation), 2005. Microbiological criteria for food stuffs. In: Official Journal of the European Union. Published online by Food Safety Research Information Office, USDA, USA. No.2073/2005.

E.l.Jakee, J., Ata-Nagwa, S., Abd El-Moez-Sherein, I., Kandiel- Mai, M., Radwan- Nermin, M., 2014. Assessment of the Prevalence of *Salmonella*e in Food. Int. J. Curr. Microbiol. App. Sci. 3, 30-42.

EL-Kewaiky, I.A., AL-Said, A.A., 2015. Microbial and Chemical quality of retailed minced meats.Assuit. Vet. Med. J. 61, 95-105.

Elnawawi, F.A., Attala, O.A., Saleh, S., 2012. Enteropathogenes of public health importance in imported frozen meat and chicken. Inter. J. Microbiol. Res. 3, 59–63.

ESS 3602/2013 (Egyptian standard specification), 2013. Egyptian standards specification for chilled meat. Egyptian Organization for Standardization and Quality Control.

FDA, 2020. Enumeration of *Escherichia coli* and the Coliform Bacteria, BAM Chapter 4: online:https://www.fda.gov/food/laboratory-methods-food/bam-chapter-4-enumeration-escherichia-coli-and-coliform-bacteria

Ge. B., Mukherjee, S., Hsu, C.H., Davis, J.A.l., Tran, T.T.T. Yang, Q., 2017. MRSA and multidrug-resistant *Staphylococcus aureus* in U.S. retail meats, 2010–2011. Food Microbiol. 62, 289–297.

Gebeyehu.A, Yousuf, M., Sebsibe, A., 2013. Evaluation of Microbial Load of Beef of Arsi Cattle in Adama Town, Oromia, Ethiopia. J. Food Process Technol. 4, 234.

Gwida, M.,Hotzel, H., Geue, L., Tomaso, H., 2014. Occurrence of *Enterobacteriaceae* in raw meat and in human samples from Egyptian retail sellers. Int Scholarly Res Notices 565671.

Hannan, A., Sidrah, S., Chaudhary, S., Barkaat, M., Arshad, M.U., 2008. Antibacterial activity of *Nigella Sativa* against clinical isolates of Methicillin resistant *Staphylococcus aureus*. J. of Ayub Medical College, Abbottabad 20, 72-74.

Hassan, H.F. and Soultan, H.M., 2004. Some bacteriological quality of buffalo minced meat, in Giza governorate. J. Egypt. Vet. Med. Assoc. 64, 353–360.

Hassanien, F.S., Shaltout, F.A., Fahmey, M.Z., Elsukkary, H.F., 2020. Bacteriological quality guides in local and imported beef and their relation to public health, Food Control Dept., Fac. Vet. Med., Benha University, Egypt. Benha Veterinary Medical Journal 39, 125-129.

Iraha, I.R., ugbo, E.C., Ilang, D.C., Oji, A.E., Ayogu, T.E., 2011. Bacteria contamination of raw meat sold in Abakaliki, Ebonyi state Nigeria. Journal of Public Health and Epidemiology 3, 49-53.

ISO, 2002a. International Organization for standardization. Microbiology of food and animal feeding stuffs - Horizontal method for the enumeration of microorganisms. Colony count technique at 30°C. 4833. https://www.iso.org/ics/07.100.30/x/

ISO, 2004. International Organization for standardization. Microbiology of food and animal feeding stuffs - Horizontal methods for the detection and enumeration of *Enterobacteriaceae*, Part 2: Colony count method. 11291, 1. https://www.iso.org/standard/34566.html

Johanna, E., 2005. Bacteriological quality of raw fresh beef post-harvesting. Master Thesis, South Africa, Faculty of Health Sciences Tshwane: University of Technology

Juarez, M., Lam, S., Bohrer, B.M., Dugan, M.E.R., Vahmani, P., Aalhus, J., Juarez, A., López-Campos, O., Prieto, N., Segura, J., 2021. Enhancing the Nutritional Value of Red Meat through Genetic and Feeding Strategies. Foods 10, 872.

Lamada-Hanan, M., Nassif-Marionette, Z., Eleiwa-Nesreen, Z., 2012. Microbiological evaluation of some chicken meat and meat products. Egypt. J. Agric. Res. 90, 279-293.

Leygonie, C., Britz, T.J., Hoffman, L.C., 2012. Meat quality comparison between fresh and frozen/thawed Ostrich Miliofibularis. Meat Science 93, 364-368.

Maarouf, A.A., Nassif-Marionette, 2008. Bacteriological studies on frozen cow meat and some meat products at Benha city. Journal of the Egyptian Vet. Med. Assoc. 68, 129-141.

MacFaddin, J.F., 2000. Biochemical Tests for Identification of Medical Bacteria, 3rd ed., Williams & Wilkins Co., Washington DC, USA.

Mansour, A.F.A., Basha, O.A.M., 2009. Hygienic Status of Imported Frozen Beef In Alexandria Markets Dept. of Bacteriology, Animal Health Research Institute, Alexandria Branch, Egypt.

Martinez, L.C., Cabrera, E.D., Perez, J.A Garay, L.E., Varela, J.J, Castillo, A, Lucia, L., Avila, M.G., Cardona, M.A., Gutierrez, P., Martinez, N.E., 2015. Quantitative distribution of *Salmonella* spp. and *Escherichia coli* on beef carcasses and raw beef at retail establishments. International Journal of Food Microbiology 210, 149 -155.

Morshdy, A.M., El-Atabany Adel, L., Hussein Mohamed, A., Nasser M.A. 2013. Detection of entertoxigenic *Staphylococcus aureus* in some meat products. Assiut. Vet. Med. J. 59, 100-106.

Morshdy, A.M., Darwish, W.S., Salah, W.M., Khalifa, S.M., 2018. Prevalence of multidrug-resistance *Staphylococcus aureus* and *Salmonella enteritidis* in meat products retailed in Zagazig city, Egypt. Slov. Vet. Res. 55, 295–301.

Naomi, B., Avraham, R., 2000. Staphylococcal Enterotoxins. Int. J. Food Microbiol. 61, 1–10.

NAS (National Academy of Science), 1985. An evaluation of the role of microbiological criteria for foods and food ingredients National Academy Press. Washington.

Ramadan, A.M., 2015. Contamination of meat products with human pathogens M.V.Sc., Alex. Univ., Egypt.

Rhoades, J.R., Duffy, G., Koutsoumanis, K., 2009. Prevalence and concentration of verocytotoxigenic *Escherichia coli*, *Salmonella* enterica and Listeria monocytogenes in the beef production chain: A Review. Food Microbiol. 26, 357–376.

Saleh E.A., Ibrahim H.A., El-Kewaiey I.A., Zaqzouq G.S., 2013. Microbiological aspects of sheep and cattle meats in El-Beheria province. Assiut Veterinary Medicine Journal 59, 192-202.

Salek, M., 2000. Microbial control of cooked meat foods and lettuces served in Beheshti Medical Sciences University restaurants. Ph.D. Thesis. 154, 63-69.

Shaltout, F.A., Maarouf, A.A., El-Kewaiey, I.A., Heweidy, A.Y., 2016. Prevalence of some foodborne microorganisms in meat and meat products. Benha Vet. Med. J. 31, 213-219.

Stagnitta, P.V., Micalizzi, B., Guzmán, A.M.S., 2006. Prevalence of some bacteria yeasts and molds in meat foods in san Luis, Argentina. Cent. Eur. J. Publ. Health 14, 141–144.

Tang, Y., Larsen, J., Kjeldgaard, J., Andersen, P.S., Skov, R., Ingmer, H., 2017. Methicillin-resistant and -susceptible *Staphylococcus aureus* from retail meat in Denmark. Int. J. Food Microbiol. 249, 72–76.

Tarabees, R.Z., Hassanin, Z.H., El-Bagoury, A.M., 2015. Polymerase Chain Reaction (PCR): An Alternative Rapid Method for Detection of Some Microbial Contamination of Meat Products. Alexandria J. Veterinary Sciences 45, 91-98.

Tassew, H., Abdissa, A., Beyene, G., Gebre-Selassie, S., 2010. Microbial flora and foodborne pathogens on minced meat and their susceptibility to antimicrobial agents, Ethiopian Journal of Health Science. 20, 137-43.

Ukut, I., Okonko, I., Ikpoh, I, Nkang, A., Udeze, A., Babalola, T., MeJeha, O., Fajobi, E., 2010. Assessment of Bacteriological quality of fresh meats sold in Calabar Metropolis, Nigeria. Electronic J. Env. Agri. and Food Chem. 9, 89-100.

USDA, 2016. United States Department of Agriculture Foreign Agricultural Service Foreign Ag Service Verified account @USDA Foreign Ag.

WHO (World Health Organization), 2016. WHO Estimates of the Global Burden of Foodborne Diseases. Report by World Health Organization.

Zafar, A., Ahmed, E., Wajiha, H., Khan, A.B., 2016. Microbiological Evaluation of Raw Meat Products Available in Local Markets of Karachi, Pakistan. Pakistan Academy of Sciences B. Life and Environmental Sciences. 53, 103–109.

Zerabruk, K., Retta, N., Muleta, D., Tefera, A.T., 2019. Assessment of microbiological safety and quality of minced meat and meat contact surfaces in selected butcher shops of Addis Ababa, Ethiopia. Journal of Food Quality 2019, Article ID 3902690.