SVU- International Journal of Veterinary Sciences, 5(3): 86-103, 2022
Print ISSN: 2535-1826 **Online ISSN: 2535-1877**

Research Article Open Access

Quality assessment and detection of multiple drug-resistant food-borne aerobic bacteria in frozen quail in Luxor and Aswan city

Zeinab Ahmed[1], Huda Elsayed[2], Nady Khairy Albarbary[3*]

[1]Department of Food Hygiene, Reference Laboratory for Veterinary Quality Control on Poultry Production, Animal Health Research Institute, Agriculture Research Center, Luxor, Egypt, [2]Reference Lab for Safety Analysis of Food of Animal Origin, Animal Health Research Institute, Agriculture Research Center, Giza, Egypt, [3]Department of Food Hygiene, Faculty of Veterinary Medicine, Aswan University

Abstract

Quail meat is a delicate white game meat with extremely low skin fat and low cholesterol value. It is rich in micronutrients and vitamins including vitamin B6, niacin, thiamin, pantothenic acid and riboflavin, folate and vitamin E and K. It is therefore recommended for people with high cholesterol levels. Fifty random samples were collected from different restaurants in Luxor and Aswan cities, Egypt to evaluate the quality of frozen wild quail meat. The investigation revealed that (8%), (8%), and (12 %) of the examined samples were contaminated with *E.coli*, *Staphylococcus aureus*, and *Salmonella* spp., respectively as well as the mean values of *APC*, *Coliform*, and *S. aureus* counts were $4.4\times10^4\pm0.074$, $2.2\times10^3\pm0.094$ and $1.2\times10\pm1.1$ respectively. Serotyping revealed that the investigated *E. coli* isolates belonged to 3 different O-serogroups comprising O_{125} (50%), O_{55} (25%), and O_{86a} (25%) while the examined *Salmonella* isolates including *Salmonella* Othmarschen (16.6%), *Salmonella* Livingstone (16.6%), *Salmonella Kentucky* (16.6%), *Salmonella Tado* (16.6%) and *Salmonella enterica Subspecies Salamae* (33.3%). Antimicrobial susceptibility testing for *E. coli* isolates revealed that they were sensitive to Colistin sulfate, Nalidixic acid, and Ceftriaxone while they were resistant to Gentamycin, Streptomycin. *S. aureus* isolates were sensitive to Ampicillin and Vancomycin while resistant to Erythromycin, Chloramphenicol, and Tetracycline. In addition, *Salmonella* isolates were sensitive to Amoxicillin and Streptomycin while resistant to Colistin sulfate. Moreover, the mean values of pH, total basic nitrogen (TVB-N mg/100gm), and Thiobarbituric acid (TBA mg/Kg) were 5.9±0.01, and 12.1±0.2 and 0.72±0.03, respectively.

Keywords:

Aerobic bacteria, Meat quality, pH, Quail, Thiobarbituric acid, Total volatile basic Nitrogen.

DOI: 10.21608/svu.2022.145199.1207 Received: June 16, 2022 Accepted: August 29, 2022 Published: September 24, 2022

*Corresponding Author: Nady Khairy Albarbary E-mail: nadyvet82@yahoo.com

Citation: Ahmed et al., Quality assessment and detection of multiple drug-resistant food-borne aerobic bacteria in frozen quail in Luxor and Aswan city. SVU-IJVS 2022, 5(3): 86-103.

Competing interest: The authors have declared that no competing interest exists.

Introduction

Quail meat is a sweet and subtle white game meat with extremely low skin fat and low cholesterol value; also it is rich in micronutrients and a wide range of vitamins including vitamin B6, niacin, thiamin, pantothenic acid and riboflavin, and vitamin E and K (MichaelImchen, 2014). Quail meat is an ideal food for all groups of ages, due to its high meat yield, low shrinkage during cooking and serving (El-Dengawy et al. 2010) and considered superior to red meat because it contains low fat, low cholesterol, and has a high amount of iron (Liu et al., 2012) so the quail meat production represents a promising source of protein in developing countries including Egypt. The wild quails were exposed to many stress factors which cause depletion of muscle glycogen and make the gut more permeable to bacteria resulting in a high bacterial population in muscle and reducing meat quality and shelf-life (Mousa et al. 2016). Despite the high value of quail meat, there is no accurate control and inspection of quail carcasses. Therefore, the possibility for transmission of some bacteria such as E. coli, staphylococcus, and salmonella is one of the main causes of food poisoning. Hence, quail carcass contamination during slaughtering and processing is a major risk for subsequent foodborne infections in humans (Freitas et al. 2013; Kanwal et al. 2015). Furthermore, foodborne pathogens are of major public health concern throughout the world. Raw and undercooked quail meat is a rich source of E. coli, Salmonella and Shigella (Darwish et al. 2015). These pathogens can be transmitted to humans by consuming contaminated food and can lead to the risk of food-borne illness (Hara-Kudo et al. 2012). Such pathogenic strains have special adhesion fimbriae, and intestinal mucosa, damaging the absorptive surface of the intestine and leading to diarrhea (Vincent et al. 2010). Several reports took into an account the isolation and characterization of bacterial pathogens such as E. coli, Staphylococci, and Salmonella, from quail and quail products (Wang et al. 2010). The possible sources of quail meat contamination, the Public health importance of the isolated bacteria, and the hygienic measures which should be imposed were discussed. Therefore, the present study aimed to throw light on the bacteriological and chemical criteria of frozen quail meat and its suitability for human consumption.

Materials and methods

Fifty (n=50) frozen quail carcass were collected randomly for 3 months during the year 2019-2020 from different supermarkets in Luxor and Aswan City. All samples were handled aseptically to prevent cross-contamination using sterile sampling materials (Middleton *et al.* 2005). The samples were wrapped, identified, and transported in an icebox container to RLQP, Animal Health Institute, Luxor branch, for bacteriological examination.

1. Samples preparation:

Sample preparation was done according to (APHA, 2001).

2. Bacteriological examination:

A. Determination of Aerobic Plate Count (ISO, 4833-1/2013), **Coliform count** (ISO, 4832/2006), and ***S. aureus*** count (Quinn *et al.* 2002).

B. Isolation of some foodborne pathogens:

It was done according to Quinn et al. (2002).

C. Identification of some foodborne pathogens:

It was performed as described by Quinn *et al.* "2002". Briefly, samples were inoculated into the nutrient broth at 37º for 24 hours, and a loopful was streaked into Baird Parker Agar for isolation of *S. aureus*, MacConkey agar for isolation of Gram-negative bacteria. Identification of bacteria was performed according to their colony characters, Gram's staining, and various biochemical reactions.

D. Serotyping of food-borne isolates:

Serological identification of *Salmonella* was performed according to (Popof and Le Minor, 2001) for determination of somatic antigen (*O*) and Flagler antigen (*H*) and *E. coli* according to (Lee *et al.* 2009).

3. Antimicrobial susceptibility testing:

The antimicrobial sensitivity test was performed according to the reference standard by the Clinical and Laboratory Standard Institute (CLSI, 2018) using the disc diffusion method. Different antimicrobials were used such as Tetracycline, Erythromycin, Ampicillin, Amoxicillin, Sulphamethazone, Nalidixic acid, Streptomycin, Gentamycin, Ciprofloxacin, and Norfloxacin.

4. Chemical evaluation:

A. Determination of pH value:

It was carried out according to AOAC, (2012).

B. Determination of Total Volatile Basic Nitrogen (TVBN) mg%:

It was done according to (E.O.S 63/10, 2006).

C. Determination of Thio-barbituric Acid Number (TBA) mg/Kg:

It was carried out according to (E.O.S 63/9, 2006).

Statistical analysis:

Data statistical analysis was performed by SPSS 16.0 statistical software, (2001). Differences among means were determined using t-test.

Result:

The occurrence of bacterial contamination in frozen quail meat revealed contamination with *E. coli*, *S. aureus*, and *Salmonella* (Table 1).

The bacterial count (aerobic, coliform and *S. aureus*) and acceptability of the examined frozen quail meat samples were presented in Table 2.

Table 1. Occurrence of bacterial contamination in frozen quail meat samples (n=50):

Examined bacteria	examined samples	Isolated bacteria	
	No	No	%
E. coli	50	4	8
S. aureus	50	4	8
Salmonella	50	6	12

Table 2. Prevalence of subclinical mastitis in the examined cows according to the affected quarters:

Counts	Min.	Max.	Mean ±SE	EOS* (1090/2019)	Non-accepted samples	
					No	%
Aerobic plate	**1.0×10^3**	**9.9×10^4**	**$4.4 \times 10^4 \pm 0.074$**	**$< 10^5$ Cuf/g**	**0**	**0**
Coliform	**1.0×10^2**	**9.0×10^3**	**$2.2 \times 10^3 \pm 0.094$**	**$< 10^2$ Cuf/g**	**6**	**12**
S. aureus	**1.0×10**	**2.0×10**	**$1.2 \times 10 \pm 1.1$**	**$< 10^2$ Cuf/g**	**0**	**0**

*EOS: Egyptian organization for standardization.

Table 3 showed the Serological identification of isolated E. coli in frozen quail meat samples.

The incidence of coagulase-positive *S. aureus* in examined samples was shown in Table 4. While Table 5 illustrated the serological identification of isolated *Salmonella* of examined samples.

The results of the sensitivity tests for *E. coli*, *S. aureus,* and Salmonella in the examined samples were presented in Table 6, Table 7, and Table 8, respectively.

The results of chemical parameters (pH, TVN, and TBA) and acceptability of frozen quail meat samples were presented in Table 9.

Table 3. Serological identification of isolated *E. coli* in frozen quail meat samples:

NO. of isolated bacteria	Serotype	No.	%
4	**O125 :H2**	**2**	**50**
	O55: H2	**1**	**25**
	O86a:H1	**1**	**25**

Table 4. Incidence of coagulase-positive *S. aureus* in examined samples:

NO. of isolated bacteria	Positive coagulase	
	No.	%
4	4	100

Table 5. Serological identification of isolated *Salmonella* of examined samples:

NO. of isolated bacteria	Identified strains	Group	Antigenic structure	
			O	H
6	***S.* Othmarschen**	**O**	**6,7,14**	**g, m,(t)**
	S. Livingstone	**O**	**6,7,14**	**d: L, W**
	S. Kentucky	**O**	**8,20**	**i: Z6**
	S. Tado	**O**	**8,20**	**C: Z_6**
	S. enterica Subspecies Salamae	**O**	**1.9.12**	**H,g,m,(S),t:(1,5.7)**
	Salmonella enterica Subspecies Salamae	**O**	**6.7**	**g.m,(S),t:e,n,x**

Table 6. Sensitivity test for *E. coli in* samples:

Antibiotic	*E. coli* isolates								
	O125 : H2			O86a : H1			O55 : H2		
	S	I	R	S	I	R	S	I	R
Gentamycin(10ug)			R			R			R
Neomycin(30ug)		I				R			R
Streptomycin(10ug)			R			R			R
Amoxicillin(25ug)			R			R		I	
Sulphamethoxazole(25ug)			R	S					R
Colistin sulphate(10ug)	S			S			S		
Ciprofloxacin(5ug)	S					R			R
Nalidixic acid(10ug)			R	S			S		
Ceftriaxone			R	S			S		

Table 7. Sensitivity test for *S. aureus in* samples:

Antibiotic	Sample 1			Sample 2			Sample 3			Sample 4		
	S	I	R	S	I	R	S	I	R	S	I	R
Erythromycin (15ug)			R			R		I				R
Vancomycin (15ug)	S			S			S			S		
Tetracycline (30ug)			R			R			R			R
Ampicillin (10ug)	S			S			S					R
Chlroamphenicol (30ug)			R			R			R		I	

Table 8. Sensitivity test for *Salmonella in* samples:

Antibiotic disc	*Salmonella* Isolates														
	S. othmarsachen			*S. Livingstone*			*S. Kentucky*			*S. Tado*			*S. Enterica Subspp Salamae*		
	S	I	R	S	I	R	S	I	R	S	I	R	S	I	R
Gentamycin (10ug)	S			S					R				S		
Neomycin (30ug)	S				I			I			I			I	
Streptomycin (10ug)	S			S			S			S			S		
Amoxicillin (25ug)	S			S			S			S			S		
Sulphamethoxazole (25ug)	S			S					R			R	S		
Colistin sulfate (10ug)			R			R						R			**R**
Ciprofloxacin (5ug)	S			S			S					R	S		
Nalidixic acid (10ug)															
Ceftriaxone (10ug)	S			S					R			R	S		

Table 9. Statistical analytical results of chemical parameters and acceptability of frozen quail meat samples (n=50):

Chemical parameters	Min.	Max.	Mean± SE	EOS* (1090/2019)	Non-accepted samples	
					NO	%
pH	5.5	6.3	5.9±0.01	5.5-6.5	6	12
TVN mg/100gm	6.3	23.5	12.2±0.2	< 20 mg/100g	4	8
TBA mg/kg	0.12	0.91	0.52±0.03	< 0.9 mg/kg	3	6

EOS: Egyptian organization for standardization.

Discussion

Foodborne diseases are a global issue, and a unified and joint approach by all countries and the relevant international organizations is a prerequisite for the identification and control of all emerging foodborne problems that threaten human health and international trade (Van de Venter, 2000). In the present study, as clarified in Table (1), *E. coli* was isolated from the examined with a prevalence of (8%), these results were lower than El-Dengawy and Nassar (2010) were isolated *E.coli* in (30%) of examined samples while these results were higher than Edris et al. (2011) were recorded (4%). Isolation of *E. coli* in this study emphasizes that they could be a potential source of human infection and gives an indication of the fecal contamination during handling and processing. The presence of *E. coli* may affect the quality of meat which causes economic losses (ICMSF, 1996). As well *S. aureus* was isolated from frozen quail meat samples with a prevalence of 8%, Furthermore, in contrast to these results, very higher incidence of *S. aureus* (40%) was recorded by Edris et al. (2011) while these results higher than Mousa *et al.* (2016) detected *S. aureus* in (4%) of examined samples. The higher contamination rate of *S. aureus* might be attributed to excessive handling of meat by workers during processing, contaminated water used, bad personal hygiene, and cross-contamination (Waldroup 1996). In addition, *Salmonella* was isolated from frozen quail meat with a prevalence of (12%), and these results were higher than that reported by Mousa *et al.* (2016) who failed to detect *Salmonella* while lower than the result obtained by Amna *et al.* (2015) who detected *salmonella* with an incidence of (66.6%). In these studies, *Salmonella enterica* incidence in the examined samples agreed with the results of Bacci et al. (2012) who detected *Salmonella Kentucky* with an incidence of (16.6%) and higher than Lamiaa et al. (2019) who detected *Salmonella Kentucky* with an incidence of (3.3%). In this study as illustrated in Table (2), it was found that the mean value of *APC* was (4.4×10^4 cfu/g) these results nearly similar to that recorded by Mousa et al. (2016) who recorded *APC* (5.1×10^6 cfu/g) while disagreed with those of Edris et al. (2011) who documented that *APC* was (9 x 10^4 cfu/g). The *APC* of frozen

quail may be attributed to unsatisfactory sanitation and contamination of materials during handling, processing, and distribution as well as insufficient chilling and freezing that may increase the existing organisms (Thatcher and Clark, 1973). Also, the results showed that the mean value of coliform was (2.2×10^3 cfu/g), the results agreed with that of El-Dengawy and Nassar (2010) who reported ($3x10^3$ cfu/g) while opposing that of Mousa *et al.* (2016) who noted coliform count was (8.6×10^3 cfu/g) as well Edris et al. (2011) who reported ($5.7x10^3\pm1.45x10^3$ cfu/g). The occurrence of coliforms may be credited to direct or indirect fecal contamination from either human or animal sources resulting in inferior meat quality. The mean value of *S. aureus* count was (1.2×10 cfu/g) as reported in this study and this was nearly reported by Naeem et al. (2018) who detected *S. aureus* count of (2.21×10 cfu/g). The presence of *S. aureus* in food indicated contamination of handlers and inadequately cleaned equipment. The decrease in the count may due to the effect of freezing application (-18±2°C) on bacteria that led to the destruction of the cell membrane and DNA denaturation of bacterial cells causing the death of the bacteria during freezing (Pavlov, 2007; Sonale et al. 2014;) as well *S. aureus* count of quail meat was also found to decline gradually during frozen storage of 90 days. Serotyping is a common way to characterize Shiga toxin-producing *E. coli* strains and is based on the somatic antigen (O) and flagellar antigen (H) (Gyles *et al.* 2007). As illustrated in Table (3), serotyping of (4) *E. coli* isolates revealed that they belonged to (3) different O-serogroups including O_{125} (50%), O_{55} (25%), and O_{86a} (25%), and the results agreed with findings of Varnam and Evans (1991) who recorded that O_{55} are the most predominant serotypes of *E. coli* among examined samples. As well these results were nearly similar to the results of Kudakwashe et al. (2013), Zende et al. (2013), and Hassanin et al. (2014). Furthermore, the serotyping of *Salmonella* spp. isolates (Table 5) showed a major variety of serotypes which included *S. Othmarschen, S. Livingstone, S. Kentucky, S. Tado, S. enterica Subspecies Salamae, S. enterica* Subspecies *Salamae*. Harsha et al., (2011) and Bacci et al. (2012) recorded the most frequently isolated serotypes in the quail samples *S. Enteritidis* (17.1%). Similarly, Freitas et al., (2013) and Udhayavel et al., (2016) isolated different types of *Salmonella* spp. identified *S. enterica* subspecies *Enterica; S. Corvalis, S. Give, S. Lexington, S. Minnesota, S. Schwarzengrund, S. Rissen, and S. Typhimurium*.

The indiscriminate use of antibiotics has been paralleled by a significant increase in the number of reports of resistant bacteria isolated (Tendencia and de la Pena, 2002). In the present study (Table 6), antimicrobial susceptibility testing for *E. coli*

isolates revealed that they were resistant to Gentamycin, Amoxicillin, Sulfa methoxazole, Streptomycin, Nalidixic acid, and Cefirioxacin. These results were nearly similar to those reported by Roy et al. (2006) and Farghaly et al. (2017) on other hand Apata (2009) reported that 10% of the strains were found resistant to ciprofloxacin. Table (7) displayed the resistance of *S. aureus* to tetracycline and chloramphenicol. These results were nearly similar to those reported by Farghaly et al. (2017) while they showed the highest resistance to erythromycin were nearly similar to those reported by Yusra *et al.* (2019). Furthermore, increased numbers of strains resistant to erythromycin (39%), and tetracycline (14%) was observed by Apata (2009). In addition, Suleiman (2013) reported that all the 54 *S. aureus* isolates recovered were resistant to ampicillin and erythromycin but susceptible to ciprofloxacin, and gentamycin. Similar patterns of antimicrobial susceptibility have been reported by Otalu et al. (2011), Pesavento et al. (2007) Waters et al. (2011), and Leonard and Markey (2008) where the occurrence of multidrug-resistant *S. aureus* in poultry is rather frequent. However, Geidam et al. (2012b) reported a lower resistance of 53% and 85% for ampicillin and erythromycin respectively. Tables (8), show the antimicrobial susceptibility testing for *Salmonella* isolates revealed that resisted to less extent some strains of Gentamycin, Sulfa methoxazole, clostin, ciprofloxacin, and Cefirioxacin. Moreover, these results disagreed with Haritha (2019) and Apata (2009) showed that 80% and 59% of the isolated strains were resistant to tetracycline and erythromycin, respectively. As well the result of Jahan *et al.* (2018) and Hyeon et al. (2011) indicated that the isolated *Salmonella* showed resistant tetracycline, Erythromycin, and Colistine sulfate. Parvej et al. (2016) found that 50% of isolates were resistant to Colistin sulfate and 80% were sensitive to Neomycin. This indicated that Colistin sulfate is becoming resistant due to indiscriminate and unwise use. All the isolates showed 100% sensitivity towards Ciprofloxacin, as reported by Ramya et al. (2013), who found 100% susceptibility of *Salmonella spp.* to Ciprofloxacin followed by Amoxicillin (82%). The antibiotic-resistant genes of these isolates may transfer to *Salmonella* which may infect both humans and animals hindering their health (Wakawa et al., 2015). In this respect, gastro-intestinal commensal bacteria constitute a reservoir of resistance genes for pathogenic bacteria. Their level of resistance is considered to be a good indicator of selection pressure for antibiotic use and for resistance problems to be expected in pathogens. Therefore, a concerted effort should be made to maintain sanitary conditions in processing, preparation and handling, packaging, transportation, and storage of

quail carcass, periodical sanitation of utensils, chilling rooms, and cold stores, and periodical examination of workers and hand washing facilities should be present. These differences in antimicrobial susceptibility may be attributed to the use of different antibiotics in different settings and purposes as well as by humans and animals in addition to the different applied hygienic measures (Saqr et al., 2016).

Results recorded in table (9) revealed that pH values of examined frozen quail samples ranged from 5.5 to 6.3 with a mean value of 5.9±0.01, these results nearly agree with Mousa et al. (2016), El-Shehry, (2012), Youssef, (2013) and Edris et al. (2014) with a mean value of 5.8, 5.91, 5.64, 5.90 and 5.85 respectively. Higher results were achieved by Shedeed, (1999), Afifi, (2000), Abd ElAll (2001), Genchev et al. (2008), and de la Torre et al. (2012) with the mean value of (6.10), (6.15), (6.6), (6.4) and (6.5) respectively. Compared to the safe permissible limits of pH recommended by EOS 1090/2019 (5.5- 6.5), 12% of the examined samples were not within the accepted level, as shown in table (8). The decrease in pH value may be attributed to the breakdown of glycogen with the formation of lactic acid and the increase in pH may be due to the partial proteolysis leading to the increase of free alkaline groups depending on the condition of such changes (Pearson and Gillette, 1996). It is evident from the results recorded in table (8) that obtained results from TVB/N ranged from 6.3 to 23.5 with a mean value of 12.2 ± 0.2. The obtained values from the examined samples were nearly similar to those recorded by Abd El-All (2001) and Hassan (2013) with mean values of 10.94 and 11.25. This result comes in contrast to the results obtained by Youssef (2013), Edris et al., (2014), and Mousa et al., (2016) with a mean value of, 9.11± 0.33, 6.08±0.3 and 7.1 ± 0.32but lower than the results of Afifi (2000) with a mean value of 13.87±0.18 (mg%). According to the safe permissible limits stipulated by EOS 1090/2019; TVB/N lower than 20mg/100gm, 8% of the examined samples were higher than the safe standard limit. TVB/N in poultry meat may be increased as the days of storage increased (Reddy et al., 1970), the increase in TVB/N value in meat during storage might be attributed to the breakdown of protein as a result of the activity of microbial strains and proteolytic enzymes (Yassien, 2003; Alina and Ovidiu, 2007). The increase to critical values indicates incipient spoilage of chicken meat product samples after different periods of storage (Hassanin and Hassan, 2003) due to ammonia is one of the most spoilage end products in spoiled meat and meat products which is directly responsible for spoilage odors and flavors, it is considered as an indicator for amino acid degradation by bacteria and it can be measured as total volatile basic nitrogen Gill, (1983). Accordingly, TVN can be

considered a reliable indicative measure for the quality of various food articles especially poultry and its products. Furthermore, from the results recorded in a table (8), it is evident that TBA (mg%) in the examined samples of quail meats varied from 0.12 to 0.91 with an average of 0.52±0.03. Lower results were obtained by de la Torre *et al.* (2012), Mousa et al. (2016), Afifi, (2000), Youssef, (2013), and Edris et al. (2014) with an average of 0.18, 0.23, 0.119, 0.09 and 0.218 respectively. A furthermore higher result was reported by Abd El-All (2001) with an average of (1.1). The oxidative rancidity in poultry meat was evaluated by measuring malonaldehyde in fat meat with an improved Thiobarbituric acid (TBA) assay with antioxidant protection (Abd El-Kader, 1996). Compared to the safe permissible limits approved by EOS 1090/2019, TBA lower than 0.9mg/kg, 6% of the examined samples were higher than the safe standard value. The quality of poultry meat products during the chilling or freezing depends greatly on TBA value as recommended by (Hassan and Shaltout, 2004). The variation of TBA values of examined samples could be attributed to the variation of the fat content of different samples under examination and storage life and development of off-flavors known as rancidity is due to lipid oxidation (Owens, 2001), and so the Thiobarbituric acid value is routinely used as an index of lipid oxidation in stored meat products (Abd El-Kader, 1996). The hygienic quality precautions of foodstuff should be monitored including antemortem and postmortem examination, every so often cleaning and disinfecting the instruments used in slaughtering, processing, and sanitation of quail slaughter halls, equipment, utensils, chilling rooms, and cold stores (Tsola et al., 2008).

Conclusion

In the present study, it could be concluded that the examined frozen quail meat was contaminated with various microorganisms including *Salmonella* spp., *S. aureus,* and *E. coli* reflecting unhygienic measures and unsuitable environmental conditions during handling, transporting, processing, and storage. As well there were misused antibiotics resulting in multiple antibiotic-resistant strains of obtained bacteria. Furthermore, this study showed that differentiation in pH, TVBN, and TBA values occur between examined samples.

Conflict of interest statement

The authors declare that they have no conflict of interest.

References

Abd El-All HM (2001). Further studies on the meat quality of game birds. Ph.D., Thesis, Faculty of Veterinary Medicine, Cairo University.

Abd El-Kader ZM (1996). Lipid oxidation in chicken as affected by cooking and

frozen storage. Nahrung, 40(1): 21- 42.

Afifi JS (2000). Chemical studies on some poultry meat products. Master, Thesis, Faculty of Veterinary Medicine, Zagazig University.

Alina H, Ovidiu T (2007). Determination of total protein in some meat products. Analele Stiintifice ale Universitatii, Alexandru loan Cuza Sectiunea Genetica si Biologie Moleculara,TOM VIII.

American Public Health Association (A.P.H.A. 2001). Compendium of Methods for the Microbiological Examination of Foods. 3rd Ed., Edwards Brothers. Washington D.C., USA.

Amna K, Ali A, Tanveer H, Iqra S, Ayesha T, Asfa R, Javed M, Mawra G (2015). Detection of *Escherichia coli* and *Salmonella* from retelling quail meat through optimizes multiplex PCR, Pakistan Journal of Agriculture Sciences, 52(3): 809-813.

Apata DF (2009). Antibiotic Resistance in Poultry International Journal of Poultry Science., 8 (4): 404-408

Bacci C, Boni E, Alpigiani I, Lanzoni E, Bonardi S, Brindani F (2012). Phenotypic and genotypic features of antibiotic resistance in Salmonella enterica isolated from chicken meat and chicken and quail carcasses. International Journal of Food Microbiology, 160 (1):16-23.

Clinical and Laboratory Standard Institute (CLSI, 2018). Performance Standards for Antimicrobial Disk Susceptibility Testing. CLSI Supplement M100. 28th ed. CLSI, Wayne, PA.

Darwish, W.S.; Eldin, W.F.S. and Eldesoky, K.I. (2015): Prevalence, molecular characterization and antibiotic susceptibility of *E. coli* isolated from duck meat and giblets. J. of Food Safety. 35(3): 410-415.

de la Torre C, Conte-Júnior C, da Cruz Silva Canto A, Monteiro M, da Costa Lima B, Mársico E, Mano S, Franco O (2012). Biochemical changes in alternative poultry meat during refrigerated storage. Revista Brasileira de Ciência Veterinária, 19: 195-200.

Edris AM, Shaltout FA, Arab WS (2011). Bacterial Evaluation of Quail Meat Department of Food Control, Faculty of Veterinary Medicine (Moshtohor) Zagazig University, Benha branch.

Edris AM, Reham AA, Dalia AS, Aya FM (2014). Chemical indices of pigeon and quail

meat quality. Banha veterinary medicine Journal, 27 (2):363-367.

Egyptian Organization for Standardization ‘EOS, 1090’’ (2019). Egyptian Organization for Standardization and quality control. Egyptian Standards for frozen poultry and rabbit.

Egyptian Organization for Standardization ‘EOS, 63/9’ (2006). Egyptian Organization for Standardization and quality control. Egyptian Standards for poultry meat products treated with heat.

Egyptian Organization for Standardization ‘EOS, 63/10’ (2006). Egyptian Organization for Standardization and quality control. Egyptian Standards for poultry meat products treated with heat.

EI-Dengawy RA and Nassar AM (2010). Investigation of the nutritive value and microbiological quality of wild quail carcasses. Nahrung, 4 (5): 50-54.

El-Shehry-Eman, M.A. (2012): Chemical analysis of chicken meat with relation to its quality. Ph. D. Thesis, Faculty of Veterinary Medicine, Benha University.

Farghaly EM, Samy A, Roshdy H (2017). Wide Prevalence of Critically Important Antibiotic Resistance in Egyptian Quail Farms with Mixed Infections. Veterinary Sciences: Research and Reviews, 3 (1): 17-24.

Finegold SM and Martin WG (1982). Bailey and Scott's Diagnostic Microbiology, (Ed.6) The C.V. Mosby Company. St. Louis, Toronto, London.

Freitas, Neto, O.C. de; Angela, H.L. da; Soares,N.M.; Guastalli, E.A.L.; Almeida, A.M. de and Berchieri Junior, A. (2013): Salmonella spp. in meat-type quails (Coturnix coturnix coturnix) in the State of Sao Paulo, Brazil. Brazilian J. of Poultry Science. 15(3):277-281.

Geidam YA, Zakaria Z, Abdul Aziz S, Bejo S.K., Abu J, Omar S (2012b). High prevalence of multidrug-resistant Bacteria in selected poultry farms in Selangor, Malaysia. Asian Journal of Animal and Veterinary Advances 7(9): 891- 897

Genchev A, Ribarski S, Michailova G, Dinkov D (2008). Slaughter characteristics and chemical composition of the meat from Japanese quail (Coturnix japonica). Journal of Animal Science, 5:8-12.

Gill CO (1983). Meat spoilage and evaluation of potential storage life of fresh meat.

Journal of Food Protection, 46 (5): 444- 452.

Gyles, C.L. (2007): Shiga toxin-producing Escherichia coli. Journal of Animal Science 85(13): 45-62.

Hara-Kudo Y, Konuma H, Kamata Y, Miyahara M, Takatori K, Onoue Y, Sugita-Konishi Y, Ohnishi T (2012). Prevalence of the main foodborne pathogens in retail food under the national food surveillance system in Japan. Food Addict. Contam. Part A Chem. Anal Control Expo. Risk Assess. 30:1450-1458.

Haritha Routhu (2019). Antimicrobial susceptibility and molecular characterization of resistance genes in Salmonella isolated from quail samples. The Pharma Innovation Journal 8 (12): 290-294.

Harsha HT, Reshmi RR, Divya PS, Mujeeb RK, Mohamed H A (2011). Prevalence and antibiotic resistance of Salmonella from the eggs of commercial samples. Journal of Microbiology and Infectious Disease, 1 (3): 93-100.

Hassan, F. (2013). Chemical profile of some frozen poultry meats Master, Thesis, Faculty of Veterinary Medicine, Benha University.

Hassan, M.A., Shaltout, F. (2004). Comparative study on the storage stability of beef, chicken meat, and fish at chilling temperature, Alex. J. Vet. Sci., 20-21:30. Egypt.

Hassanin FM and Hassan, MA (2003). Chemical indices of incipient deterioration in chicken cut-up products. Benha Veterinary Medicine Journal, 14(2):54-65. Egypt.

Hassanin F, Salem AM, Shorbagy EM, Kholy RL (2014). Traditional and recent techniques for detection of *Escherichia coli* in fresh chicken cuts and giblets. Benha veterinary medical journal. 26(2): 21-29.

Hyeon JY, Chon JW, Hwang IG, Kwak HS, Kim MS, Kim SK, Choi IS, Song CE, Park C, Seo KH (2011). Prevalence, antibiotic resistance, and molecular characterization of *Salmonella* serovars in retail meat products. Journal of Food Protection. 74(1):161–166.

ICMSF (1996). Microorganisms in food. Their significance and methods of enumeration. 3rd Edition. University of Toronto Press, Toronto, Canada.

ISO 6888 (1999). Microbiology of food and animal feeding stuff, Horizontal method for the enumeration of *Staphylococcus aureus* and other species, Part 1.

ISO 4832 (2006). Horizontal method for the enumeration of *coliforms* - *Colony count* technique.

ISO 4833 (2013). Horizontal method for the enumeration of microorganisms *Colony count* technique in at 30°C by the pour plate technique.

Jahan S, Asief HZ, Nazmul HN, Shafiqul I, Bahanur R, Marzia R (2018). Molecular detection and antibiogram of *Salmonella spp*. from apparently healthy Japanese quails of three different quail farms in Mymensingh. Journal of Advanced Veterinary Animal Research, 5(1): 60-66.

Kanwal, Amna; Sheikh, A.A.; Masood Rabbani;Tanveer Hussain; Iqra Safdar; Ayesha Tabassum; Asfa Rasool; Javed Muhammad and Mawra, Gohar (2015): Detection of *E. coli* and Salmonella from retail quail meat through optimized multiplex PCR. Pakistan Journal of Agricultural Sciences. 52(3): 809-813.

Kudakwashe M, Huu AD, Edward W, Mills CN, Cutter EL, Roberts CD (2013). Incidence of Shiga toxin-producing *Escherichia coli* strains in beef, pork, chicken, deer, boar, bison, and rabbit. Journal of Veterinary Diagnostic Investigation 25 (2): 254–258.

Lamiaa G, Kamal H, Mohamed M, Abbas A (2019). Effect of some essential oils on salmonella kentucky isolated from quail meat retailed in alexandria markets Alexandria Journal of Veterinary Sciences. 61 (1): 179-184.

Lee GY, Jang HI, Hwang IG, Rhee MS (2009). Prevalence and classification of pathogenic *Escherichia coli* isolated from fresh beef, poultry, and pork in Korea. International journal of food microbiology, 134: 196-200.

Leonard FC and Markey BK (2008). Methicillin-resistant *Staphylococcus aureus* in animals: a review. The Veterinary Journal, 175: 27-36.

Liu, X.D., Jayasena, D.D., Jung, Y., Jung, S., Kang, B.S., Heo, K.N., Lee, J.H., Jo, C. (2012). Differential proteome analysis of breast and thigh muscles between Korean native chickens and commercial broilers. Asian Australas. Journal of Animal Science; 25:895–902

MichaelImchen (2014). Benefits about quail meat and egg Sunday post. The online edition of Nagaland's first and foremost news daily. Sunday, April 27.

Middleton JR, Fales WH, Luby CD, Landsay Oaks J, Sanchez S, Kinyon JM, Wu CC, Maddox CW and Hartmann F (2005). Surveillance of

Staphylococcus aureus in veterinary teaching hospitals. Journal of Clinical Microbiology, 43(6): 2916-2919.

Mousa M, Nehad IE, Amal MA, Hala AM, Adel M (2016). Quality Assessment of Frozen Quail in Kafr EL-Sheikh Governorate Alexandria Journal of Veterinary Sciences Jan. 48(1): 57-61.

Naeem N, Muhammad AKh, Akeela A, Shabbir H, Syeda M (2018). Assessment of Physical and Microbiological Characteristics of Quail Meat During Storage. LGU, Journal of Life Science. 2 (4).

Official Methods of Analysis of the Association of Official Analytical Chemists (AOAC, 2012). International 17th Edition Revision, 1, U.S.A.

Otalu OJ, Kabir J, Okolocha EC and Umoh VJ (2011). Multi-drug Resistant Coagulase Positive *Staphylococcus aureus* from Live and Slaughtered Chickens in Zaria, Nigeria. International Journal of Poultry Science 10 (11): 871-875.

Owens CM (2001). Coated poultry products. In poultry meat processing. Ed. Sams, A. R. CRC, Press.

Parvej MS, Nazir KHMNH, Rahman MB, Jahan M, Khan MFR, Rahman M (2016). Prevalence and characterization of multi-drug resistant *Salmonella Enterica* serovar Gallinarum biovar Pullorum and Gallinarum from chicken. Veterinary World. 9 (1): 65–70.

Pavlov A (2007). Changes in meat from aquaculture species during storage at low temperature and attempts for differentiation between thawed-frozen and fresh chilled meat. A review Bulgarian. Journal of Veterinary Medicine, 10: 151-154.

Pearson AM and Gillette TA (1996). Processed meats. 3rd Ed New, York Albany, Bonn, Boston, London

Pesavento G, Ducci B, Comodo N and Lo Nostro A (2007). Antimicrobial resistance profile of *Staphylococcus aureus* isolated from raw meat: research for methicillin-resistant *Staphylococcus aureus* (MRSA). Food Control, 18: 196-200.

Popoff MY and Le-Minor L (2001). Antigenic Formulas of the *Salmonella* Serovars. 8th Rev. Edition, WHO Collaborating Centre for Reference and Research on *Salmonella*, Institut Pasteur, Paris.

Quinn PJ, Markey BK, Carter ME, Donnelly WJ, Leonard FC (2002). Veterinary microbiology and microbial

diseases. Black Well Science, chapters 26-36, 536 pp. 1st Iowa State University Press, Ames, Iowa, USA.

Ramya P, Thirtham M, Eevuri TR (2013). Antimicrobial sensitivity and resistance of *Salmonella enteritidis* isolated from natural samples. Veterinary World. 6(4):185-188.

Reddy S, Ilenrickson RI, Olson HC (1970). The influence of lactic acid cultures on ground beef quality Oklahoma Agr i. Experiment Station, Stillwater, Oklahoma. Journal of Food Science,35, 787.

Roy S, Purushothaman V, Koteeswaran A, Dhillon A (2006). Isolation, Characterization, and Antimicrobial Drug Resistance Pattern of Escherichia Coli isolated from Japanese Quailand their Environment. Journal of Applied Poultry Research, 15:442–446.

Saqr S, Khaliel R, Ibrahim MS (2016). Antibiotic resistance and virulence genes of *E. coli* isolated from fresh Nile Tilapia (Oreochromis niloticus) in EL-Behera Governorate, Egypt. Alexandria Journal of Veterinary Sciences, 48 (2): 83-90.

Shedeed NA (1999). Evaluation of microwave cooking of chicken meat. Master, Thesis, Faculty of Agriculture, Cairo University.

Sonale OV, Chappalwar AM, Devangare AA, Londhe SV (2014). Physical Properties and Microbiological Quality of Quail Breast meat during frozen storage. Journal of Veterinary Public Health, 12 (2): 99-102.

Suleiman A, Zaria1 LT, Grema HA and Ahmadu P (2013). Antimicrobial-resistant coagulase-positive *Staphylococcus aureus* from chickens in Maiduguri, Nigeria Sokoto Journal of Veterinary Sciences, Volume 11 (1): 51-55.

Tendencia EA and dela Pena LD (2002). Level and percentage recovery of resistance to oxytetracycline and oxolinic acid of bacteria from shrimp ponds. Aquaculture, 213 (1-4): 1-13.

Thatcher FS and Clark TS (1973). Microorganisms in Food, Their Significance, and methods of enumeration. Journal of The Royal Society for the Promotion of Health, 90 (2): 120.

Tsola E, Drosinos E and Zoiopoulos P (2008). Impact of poultry slaughterhouse modernization and updating of food safety management systems on the microbiological quality and safety of products. Food Control. 19 (4): 423- 431.

Udhayavel SM, Gowthaman TR, Senthilvel V, Kumar GS (2016). Isolation and identification of Salmonella enterica from Japanese quail in India. International Journal of Applied Research, 2 (12): 645-647

Van de Venter T (2000). Emerging foodborne diseases: a global responsibility. Food Nutrition Agriculture; 26: 4–13.

Varnam AH and Evans MG (1991). Food born. An illustrated textbook. Wolfe Publishing Ltd. Nc *op.* 101-118.

Vincent C, Boerlin P, Daignault D, Dozois CM, Dutil L, Galanakis C, Reid-Smith RJ, Tellier PP, Tellis PA, Ziebell K, Manges AR (2010). Food reservoir for *Escherichia coli* causing urinary tract infections. Emergency Infectious Disease. 16:88-95.

Wakawa A, Mohammed F, Mamman H (2015). Isolation and antibiotic susceptibility of *Escherichia coli* and *Salmonella gallinarum* isolated from rats in commercial poultry farms with recurrent Colibacillosis and Fowl typhoid cases in Zaria, Nigeria. Journal of Veterinary Advances. 2015; 5:1147–1152.

Waldroup, AL (1996). Contamination of raw poultry with pathogens. World's Poultry. Sci. 52:7-15.

Wang HL, Yang J, Shao Hb, Luo L, Ai Dy, Luo QP, Wen Gy, Zhang RR, Zhang L (2010). Isolation and identification of entering pathogenic E. coli and salmonella from quail and their drug sensitivity test Journal of Animal Husbandry Feed Science. 1: 078.

Waters AE, Contente-Cuomo T, Buchhagen J, Liu CM, Watson L, Pearce K (2011). Multidrug-resistant *Staphylococcus aureus* in US meat and poultry. Clinical Infectious Diseases, 52:1-4.

Yassien NM (2003). Effect of storage condition on the quality parameters of differently treated fish. Ph.D. Thesis, Fac. Of Agri, Ain Shams. Egypt.

Youssef F (2013). Chemical profile of some frozen poultry meat.ph.D. Thesis (Meat hygiene). Faculty of Veterinary Medicine, Benha University.

Yusra A, Norasikin N, Siti A, Ahmad S, John Y (2019). Prevalence and Antimicrobial Resistance of *Escherichia coli, Staphylococcus aureus,* and *Salmonella* spp. from cloacal swabs of quail Bioscience Research, 16 (SI): 46-52

Zende RJ, Chavhan DM, Suryawanshi PR, Rai AK, Vaidya VM (2013). PCR detection and serotyping of enterotoxigenic and Shiga

toxigenic *Escherichia coli* isolate obtained from chicken meat in Mumbai, India. Veterinary World, 6 (10): 770-773.