FOODBORNE PATHOGENS AND DISEASE
Volume 12, Number 5, 2015

DOI: 10.1089/fpd.2014.1882

Prevalence and Antimicrobial Resistance Profile of *Staphylococcus* Species in Chicken and Beef Raw Meat in Egypt

Kamelia M. Osman,[1] Aziza M. Amer,[2] Jihan M. Badr,[3] and Aalaa S.A. Saad[3]

Abstract

Coagulase-positive (CPS) and coagulase-negative (CNS) staphylococci cause staphylococcal food poisoning. Recently, CPS and CNS have received increasing attention due to their potential role in the dissemination of antibiotic resistance markers. The present study aimed to evaluate CPS and CNS species distribution and their antibiotic resistance profile isolated from chicken and beef meat. Fifty fresh, uncooked chicken parts and 50 beef meat cuts (local $n=27$; imported $n=23$) were used. One hundred staphylococcal isolates belonging to 11 species were isolated and identified from chicken ($n=50$) and beef ($n=50$) raw meat samples. *Staphylococcus hyicus* (26/100), *lugdunensis* (18/100), *aureus* (15/100) and *epidermidis* (14/100) were dominant. *S. aureus* was 100% resistant to penicillin and sulfamethoxazole/trimethoprim. Vancomycin-resistant *S. aureus* showed intermediate resistance (51%), which might indicate the dissemination of vancomycin resistance in the community and imply food safety hazards. The percentage of resistance to β-lactams was variable, with the highest resistance being to penicillin (94%) and lowest to ampicillin-sulbactam (22%). Antimicrobial resistance was mainly against penicillin (94%), clindamycin (90%) and sulfamethoxazole/trimethoprim (82%). The results indicate that chicken and beef raw meat are an important source of antibiotic-resistant CPS and CNS.

Introduction

The poultry industry in Egypt with a population of 1 billion broilers is estimated to produce 1.5 metric tons (MT) of poultry meat during the period of 2014 (Hassan, 2014).The investment in the poultry industry is around 25 billion Egyptian pounds, and ranks first in the Middle East (Hassan, 2014). The beef meat imports were around 230 MT in the year 2014 (USDA, 2014). Chicken meat contributes substantially to the diet in Egypt, and is an important, low-cost source of animal protein encouraging the consumption of chicken meat by a large number of consumers.

Today, according to the current List of Bacterial Names with Standing in Nomenclature (Euzéby, 2014), the genus *Staphylococcus* comprises 71 species, with 24 named subspecies. Staphylococcal food poisoning is believed to be greatly underreported (by about 25-fold) and underdiagnosed (by about 29-fold) (Doyle *et al*., 2012). The consumption of chicken and beef meat was implicated in a large number of outbreaks of staphylococcal food poisoning in humans in different countries (Argudín *et al*., 2010). Discrimination between *Staphylococcus* (*S*.) *aureus* and NSA (non-*S. aureus* staphylococci) involved in meat contamination is essential in terms of public health significance. Most staphylococci species are coagulase-negative (CNS) and they are distinguished from coagulase-positive staphylococci (CPS) by their inability to produce the enzyme coagulase. Although CPS, and especially *S. aureus*, are regarded as important pathogens in humans and animals, CNS should not be ignored in epidemiological investigations of foodborne outbreaks based on the presence of enterotoxin genes (Rall *et al*., 2010; Batista *et al*., 2013). In the last 20 years, however, the interest in CNS species has significantly increased in both human and veterinary medicine (Rogers *et al*., 2009; Braem *et al*., 2014). Information regarding the detailed prevalence of *S. aureus* and NSA isolates was insufficient in Egypt.

The aim of this study was to evaluate the occurrence of *S. aureus* and NSA and between CPS and CNS strains isolated from retail chicken and beef marketed in Cairo, Egypt, by using cultural and biochemical tests, to determine their diversity between samples and to characterize the isolated strains based on their resistance to antibiotics.

Materials and Methods

A total of 100 samples each of chicken ($n=50$) and beef (local, $n=27$ and imported, $n=23$) were randomly collected from various local supermarkets and butcher shops. All

Departments of [1]Microbiology and [2]Pharmacology, Faculty of Veterinary Medicine, Cairo University, Cairo, Egypt.
[3]Department of Poultry Diseases, Animal Health Research Institute, Dokki, Egypt.

samples collected were unprocessed raw and fresh meat. The samples were aseptically collected, and each sample was placed in a separate, sterile plastic bag. The samples were brought under refrigeration to the laboratory and analyzed within the following 2 h. The samples (25 g) were weighed into sterile stomacher bags diluted with 225-mL sterile buffered peptone water and homogenized in a stomacher for about 5 min; 0.1 mL was streaked on Baird-Parker (BP) agar supplemented with egg yolk–tellurite emulsion and incubated at 37°C for 24 h. Strains cultured on BP agar medium were identified as *S. aureus* if growth was observed and the colonies and their surrounding showed the typical morphologic characteristics after aerobic incubation at 37°C (black colonies with an opaque precipitation halo); growth of colonies without the media-typical characteristics was considered as NSA. The tube coagulate test was determined and evaluated for coagulation after 3 and 24 h of incubation. All isolates identified as NSA and CNS based on colony morphology, Gram staining (positive), catalase reaction (positive), and coagulase test (positive) were subjected to species identification by using all the conventional biochemical methods described by Thorberg and Brandstrom (2000). For novobiocin-sensitive CNS isolates identified in samples, a simplified identification system, novobiocin-sensitive CNS built on biochemical tests was used (Thorberg and Brandstrom, 2000). To confirm the isolates as *Staphylococcus*, definitive identification of all strains included in the study was performed targeting the *Staphylococcus* genus-specific 16S rRNA gene polymerase chain reaction (fragment of 756 bp); **F**: AAC TCT GTT ATT AGG GAA GAA CA and **R**: CCA CCT TCC TCC GGT TTG TCA CC as previously described (Zhang *et al*., 2004). For the positive control, *S. aureus* (ATCC 43300) reference strain was used as control for the test results.

The resistance pattern of *Staphylococcus* spp. isolates was determined using the disk-diffusion test (CLSI, 2012). Eleven antibiotics were chosen for the study based on the most used active principles in human medicine, national veterinary therapy, and according to their common use in research. The use of oxacillin/methicillin is not usually used in veterinary practice, and it was included in this study only for epidemiological purposes; the drugs tested are indicated in Table 1. *S. aureus* American Type Culture Collection (ATCC) 29213 and *S. aureus* ATCC 43300 were used as methicillin-susceptible and -resistant controls, respectively.

Results and Discussion

Cairo is the largest city in the Middle East with a population of more than 16 million. Due to overcrowding and in some areas a state of poverty, inadequate sanitary conditions and poor general hygiene are seen. Raw meat is sold and available in open-air local retail shops without appropriate temperature control and is purchased by approximately 75% of households (ElNaggar *et al*., 2006; Kader and Yahia, 2012).

Contaminated raw meat is one of the main sources of foodborne illnesses and a risk of the transmission of zoonotic infections. CPS and CNS are well established as clinical and epidemiological pathogens, and their potentially pathogenic role as foodborne pathogens should not be neglected. From the 100 samples inspected, 100 isolates (100/100; 100% isolation rate) belonging to 11 species were obtained (Table 2), from which the most dominant were *S. hyicus* (26/100), *lugdunensis* (18/100), *aureus* (15/100), and *epidermidis* (14/100). Studies have reported rates of 6% to 100% from Spain (Alvarez-Astorga *et al*., 2002), Japan (Kitai *et al*., 2005), Italy (Normanno *et al*., 2007), The Netherlands (van Loo *et al*., 2007), Nigeria (Achi and Madubuike, 2007), Jordan (Al-Tarazi *et al*., 2009), Korea (Lim *et al*., 2010), United States (Waters *et al*., 2011), Turkey (Citak and Duman, 2011), India (Arul and Saravanan, 2011), China (Wang *et al*., 2013), EFSA (2013), Egypt (EI-Jakee *et al*., 2013), and Thailand (Akbar and Anil, 2013). The isolation rate of the *Staphylococcus* species recorded in our investigation on local beef meat (3.7%) was much lower than that recorded from the imported beef meat (47.8%), while the *S. aureus* contamination constituted a significantly higher rate in the local beef meat (33.3%) than in the imported beef meat (13.0%). The isolation rates recorded in beef were higher than those previously reported by Heo *et al*. (2008), who reported there was no significance difference in the frequency of *S. aureus* isolation between imported (10.3%) and domestic (8%) raw beef samples.

The isolation and prevalence data are variable and differ between various countries, and comparison between studies is inadvisable. Nevertheless, comparisons could still be made, noting that there are limiting factors due to inherent differences in methodology (sampling techniques, sample size, type of samples, sampling seasons, and sites [geographical locations, supermarkets, groceries, butcher shops, vendors/hawkers], identification methods), packaging, display at the butcher shop and handling practices, food settings, slaughterhouse and butcher appliances (knives, slicing machines, wiping cloths, towels, and nail brushes), and in grocery store meatburger grinders (EC, 2011). These factors differ greatly between countries and even within the same country, especially in the underdeveloped world. As meat may originally become contaminated during or after processing, the great significance of slaughter hygiene should be emphasized due to the problem of the increased speed of current production lines (Jacob, 1989). The three slaughterhouse tasks most likely to contaminate meat are the removal of an animal's hide, the removal of its digestive system, and the spread of feedlots at slaughterhouses and slaughterhouse workers who are often illiterate and always overworked (EC, 2011). Other contamination sources of *S. aureus* are soil, water, dust and air, changes in eating habits, and mass catering; also, complex and lengthy food-supply procedures with increased international movement are additional contributing factors (Jacob, 1989).

In addition to these factors, the most important underestimated source is the asymptomatic food handlers, who may harbor *S. aureus* and can contaminate food during preparation (Todd *et al*., 2008). *Staphylococcus* spp. are widely found as normal flora in the nose and throat (and thus on the hands and fingertips) and on the hair and skin of more than 50% of healthy individuals (FDA, 2009). Food handlers who have skin lesions, or by sneezing or coughing, are a major source of contamination of table foods (FDA, 2009). However, testing of humans (food handlers) who came into contact with the study was not an objective of this study and therefore was never attempted. Any food that requires handling in preparation may therefore easily become contaminated. Infected wounds, lesions, and boils of food handlers

Table 1. Antibiotic Resistance Profile of Staphylococci Isolates in Chicken and Beef Raw Meat Samples

	Chicken isolates				*Beef isolates*								
					Local beef				*Imported beef*				
	S. aureus		*Non*–S. aureus *staphylococci*		S. aureus		*Non*–S. aureus *staphylococci*		S. aureus		*Non*–S. aureus *staphylococci*		*Total number of resistant isolates*
Antibiotic resistance profile	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	
VA	0	0	0	0	0	0	0	0	0	0	1	1	1
P, SXT	0	0	0	0	0	0	0	0	2	2	4	2	6
E, DA, TE	0	0	1	3	0	0	0	0	0	0	0	0	1
CN, E , DA, TE	0	0	1	4	0	0	0	0	0	0	0	0	
P, E , DA, TE	0	0	2	4	0	0	0	0	0	0	0	0	
P, E, CN, SXT	0	0	1	4	0	0	0	0	0	0	0	0	6
P, VA, SXT, CIP	0	0	0	0	0	0	0	0	0	0	1	4	
P, TE, VA, SXT	0	0	0	0	0	0	0	0	0	0	1	4	
P, OX, MET, SAM, SXT	0	0	1	5	0	0	0	0	0	0	0	0	
P, CN, E, DA, TE	0	0	2	5	0	0	0	0	0	0	0	0	
E, DA, TE, VA, SXT	0	0	1	5	0	0	0	0	0	0	0	0	6
P, CN, E, DA, SXT	0	0	0	0	0	0	0	0	0	0	1	5	
P,OX,CN,DA,SXT	0	0	0	0	0	0	0	0	0	0	1	5	
P, Ox, CN, DA, TE, CIP	0	0	3	6	0	0	0	0	0	0	0	0	
P, E, DA, TE, C, SXT	0	0	1	6	0	0	0	0	0	0	0	0	
P, CN, E, DA, TE, C	0	0	1	6	0	0	0	0	0	0	0	0	
P, OX, MET, CN, DA, SXT	0	0	1	6	0	0	2	6	0	0	2	6	
P, CN, E, DA, VA, SXT	0	0	0	0	1	6	0	0	0	0	0	0	15
CN, E, DA, TE, C, SXT	0	0	0	0	0	0	1	6	0	0	0	0	
CN, DA, TE, VA, SXT, CIP	0	0	0	0	0	0	1	6	0	0	0	0	
P, OX, CN, DA, VA, SXT	0	0	0	0	0	0	1	6	0	0	0	0	
P, OX, SAM, CN, DA, SXT	0	0	0	0	0	0	0	0	1	6	0	0	
P, Ox, CN, E , DA, TE, C	0	0	1	7	0	0	0	0	0	0	0	0	
P, OX, MET, CN, E, DA, TE	0	0	2	7	0	0	0	0	0	0	0	0	
P, OX, CN, E, DA, TE, CIP	0	0	1	7	0	0	0	0	0	0	0	0	16
P, CN, E, DA, TE, VA, SXT	0	0	1	7	0	0	0	0	0	0	0	0	

(*continued*)

TABLE 1. (CONTINUED)

Antibiotic resistance profile	*Chicken isolates*				*Beef isolates*								*Total number of resistant isolates*
					Local beef				*Imported beef*				
	S. aureus		*Non*–S. aureus *staphylococci*		S. aureus		*Non*–S. aureus *staphylococci*		S. aureus		*Non*–S. aureus *staphylococci*		
	No. of isolates	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	
P, OX, CN, E, DA ,TE, SXT	0	0	1	7	0	0	0	0	0	0	0	0	
P, E, DA, TE, VA, C, SXT	0	0	1	7	0	0	0	0	0	0	0	0	
P,CN,DA,TE,VA,SXT,CIP	0	0	0	0	0	0	1	7	0	0	1	7	
P, OX, CN, DA,VA, SXT, CIP	0	0	0	0	0	0	1	7	0	0	0	0	
P, OX, MET, SAM, CN, DA, SXT	0	0	0	0	0	0	1	7	0	0	0	0	
P, OX, MET, CN, DA, SXT, CIP	0	0	0	0	0	0	1	7	0	0	1	7	
P, OX, MET, CN, DA,VA, SXT	0	0	0	0	0	0	0	0	0	0	1	7	
P, OX, E, DA, C, SXT, CIP	0	0	0	0	0	0	0	0	0	0	1	7	
P, OX, CN, DA, TE, SXT, CIP	0	0	0	0	0	0	0	0	0	0	1	7	
P, OX, CN, E, DA, TET , SXT, CIP	0	0	1	8	0	0	0	0	0	0	0	0	
P, OX, MET, SAM, CN, E , DA, TE	0	0	1	8	0	0	0	0	0	0	0	0	
P, OX, MET, CN, E, DA, TE, SXT	0	0	2	8	0	0	0	0	0	0	0	0	
P, MET, CN, E, DA, TE, SXT, CIP	0	0	0	0	1	8	0	0	0	0	0	0	
P, OX ,CN, DA, TE, VA, SXT, CIP	0	0	0	0	2	8	0	0	0	0	0	0	
P, OX, MET, CN, DA, TE, VA, SXT	0	0	0	0	0	0	1	8	0	0	0	0	
P, OX, MET, CN, DA, VA, SXT, CIP	0	0	0	0	0	0	0	0	0	0	2	8	
P, OX, MET, CN, E, DA, TE, VA, SXT	1	9	2	9	0	0	0	0	0	0	0	0	29
P, Ox, MET, SAM, CN, E , DA, TE, SXT	1	9	1	9	0	0	0	0	0	0	0	0	
P, Ox, MET, SAM, CN, E , DA, TE, VA	0	0	1	9	0	0	0	0	0	0	0	0	
P, Ox, MET, SAM, CN, E , DA, TE, CIP	0	0	1	9	0	0	0	0	0	0	0	0	
P, OX, MET, CN, E, DA, TE , SXT, CIP	0	0	2	9	0	0	1	9	0	0	0	0	
P, OX, MET, CN, E, DA, TE, VA, SXT	0	0	3	9	0	0	0	0	0	0	1	9	

(*continued*)

Table 1. (Continued)

Antibiotic resistance profile	Chicken isolates				Beef isolates								Total number of resistant isolates
					Local beef				Imported beef				
	S. aureus		*Non*–S. aureus *staphylococci*		S. aureus		*Non*–S. aureus *staphylococci*		S. aureus		*Non*–S. aureus *staphylococci*		
	No. of isolates	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	*No. of isolates*	*No. of antibiotics*	
P, OX, MET, CN, DA, TE, VA, SXT, CIP	0	0	0	0	0	0	2	9	0	0	0	0	
P, OX, CN, E, DA, TE, VA, SXT, CIP	0	0	0	0	0	0	1	9	0	0	0	0	
P, OX, MET, CN, E, DA, VA, SXT, CIP	0	0	0	0	0	0	0	0	0	0	1	9	
P, OX, MET, SAM, E, DA, TE, VA, SXT	0	0	0	0	0	0	0	0	0	0	1	9	
P, OX, MET, CN, E , DA, C, TE, VA, SXT	1	10	1	10	0	0	0	0	0	0	0	0	
P, OX, MET, CN, E , DA, TE, VA, SXT, CIP	0	0	1	10	0	0	0	0	0	0	0	0	
P, OX, MET, SAM, E, DA, TE, VA, C, SXT	0	0	1	10	0	0	0	0	0	0	0	0	6
P,OX,MET,CN,E,DA, TE,VA, C,SXT	0	0	0	0	0	0	2	10	0	0	0	0	
P, OX, MET, CN, E, DA, TE, VA, C, SXT, CIP	0	0	3	11	2	11	1	11	0	0	0	0	
P, OX, SAM, CN, E, DA, TE, VA, C, SXT, CIP	0	0	2	11	0	0	0	0	0	0	0	0	
P, OX, MET, SAM, CN, E, DA, TE, VA, C, SXT	0	0	1	11	0	0	0	0	0	0	0	0	
P, OX, MET, SAM, E, DA, TE,VA, C, SXT, CIP	0	0	1	11	0	0	0	0	0	0	0	0	12
P, OX, MET, SAM, CN, E, DA, VA, C, SXT,CIP	0	0	0	0	1	11	0	0	0	0	0	0	
P, OX, MET, SAM, CN, E, DA, TE, VA, SXT, CIP	0	0	0	0	0	0	1	11	0	0	0	0	
P, OX, MET, SAM, CN, E, DA, TE, VA, C, SXT, CIP	0	0	1	12	1	12	0	0	0	0	0	0	2

C, chloramphenicol; CIP, ciprofloxacin; CN, gentamicin; DA, clindamycin; E, erythromycin; MET, methicillin; OX, oxacillin; P, penicillin; SAM, ampicillin-sulbactam; SXT, sulfamethoxazole/trimethoprim; TE, tetracycline; VA, vancomycin.

Table 2. Prevalence of Coagulase-Positive and Coagulase-Negative Staphylococci in Chicken and Beef Raw-Meat Samples

		Beef meat (n = *50*)			
Staphylococcus *species*	*Chicken meat* (n = *50*)	*Local* (n = *27*)	*Imported* (n = *23*)	*Total* (n = *50*)	*Total* (n = *100*)
Coagulase-positive					
aureus	3/50 (6%)	9/27 (33.3%)	3/23 (13.0%)	12/50 (23.1%)	15/100 (15%)
Coagulase-positive non–*S. aureus* staphylococci (NSA)					
hyicus	10/50 (20%)	10/27 (37%)	6/23 (26.1%)	16/50 (30.8%)	26/100 (26%)
intermedius	1/50 (2%)	3/27 (11.1%)	3/23 (13.0%)	6/50 (11.5%)	7/100 (7%)
schleiferi subsp. coagulans	—	4/27 (14.8%)	—	4/50 (7.7%)	4/100 (4%)
Total	14/50 (28%)	26/27 (96.3%)	12/23 (52.2%)	38/50 (76%)	52/100 (52%)
Coagulase negative non–*S. aureus* staphylococci (NSA)					
epidermedius	13/50 (26%)	—	1/23 (4.3%)	1/50 (2.1%)	14/100 (14%)
lugdunensis	15/50 (30%)	—	3/23 (13.0%)	3/50 (6.3%)	18/100 (18%)
haemolyticus	1/50 (2%)	—	1/23 (4.3%)	1/50 (2.1%)	2/100 (2%)
hominus	3/50 (6%)	—	1/23 (4.3%)	1/50 (2.1%)	4/100 (4%)
Schleiferi subsp. coagulans	2/50 (4%)	—	—	—	2/100 (2%)
simulans	—	—	1/23 (4.3%)	1/50 (2.1%)	1/100 (1%)
cohnii	1/50 (2%)	—	—	—	1/100 (1%)
lentus	1/50 (2%)	1/27 (3.7%)	—	1/50 (2%)	2/100 (2%)
scuri	—	—	4/23 (17.4%)	4/50 (8.3%)	4/100 (4%)
Total	36/50 (75%)	1/27 (3.7%)	11/23 (47.8%)	12/50 (25%)	48/100 (48%)

may also be sources of contamination, as well as coughing and sneezing by individuals with respiratory infections (McEntire, 2004). *S. aureus* contaminations are often associated with institutions such as hospitals, schools, and prisons, where food is often prepared in mass quantities and held until consumption (McEntire, 2004). Lack of sanitation by workers and improper time–temperature combinations during storage can lead to contamination of the product and growth of the microorganism to levels at which toxin is produced (McEntire, 2004).

Podkowik *et al*. (2012) showed that raw chicken and beef meat are an important source of CNS and that they received increasing attention due to their potential role in the dissemination of antibiotic-resistance markers in the community and imply food-safety hazards. The antimicrobial resistance profile of the tested CPS and CNS isolates to different antibiotics is recorded in Table 1. All investigated CPS and CNS isolates were resistant to at least one antibiotic. A high overall resistance to antibiotics was observed, again possibly from using antibiotics as growth promoters in animal feed (Wise, 2007), especially those commonly used for both human and animal care, which should consequently be avoided. Antimicrobial resistance was mainly against penicillin (94%), clindamycin (90%), and sulfamethoxazole/trimethoprim (82%). Vancomycin-resistant *S. aureus* showed intermediate resistance (51%), which might indicate the dissemination of vancomycin resistance in the community and imply food-safety hazards (Martins *et al*., 2013). The percentage of resistance to β-lactams was variable, with the highest resistance being to penicillin (94%) and lowest to ampicillin-sulbactam (22%). CNS are more resistant than *S. aureus* and may be a source of β-lactam resistance genes (de Medeiros *et al*., 2011).

These findings highlight the high potential risk for consumers in the absence of strict hygienic and preventative measures to avoid the presence of CPS and CNS isolates in foods. Emphasis should be placed on implementing The Codex Alimentarius Code of Hygienic Practice for Meat (CHPM), which includes the primary international standard for meat hygiene and incorporates a risk-based approach to application of sanitary measures throughout the meat production chain (OIE, 2014). Also, contamination during the distribution and consumption of the final food products must be taken into account. In addition, the potential trade impacts of beef meat garners attention to the multidrug-resistant characteristics of the isolated CPS and CNS and their possible international spread, which poses a threat to public health through their ability to be transferred to humans. Our results show the need for and importance of improving monitoring data and global cooperation in controlling food contamination, raising the sense of urgency to prevent a more threatening drug-resistant bacteria from emerging and unleashing a pandemic. Our findings also provide useful information for public health projects in Egypt, and indicate that the implementation of the Codex Committee on Food Import and Export Inspection and Certification Systems (CCFICS) and the OIE Handbook on Import Risk Analysis for Animals and Animal Products publication, which provide guidelines useful to bilateral parties to develop principles and guidelines in this area, has become a must and that food control should cover both export and import.

Disclosure Statement

No competing financial interests exist.

References

Achi OK, Madubuike CN. Prevalence and antimicrobial resistance of *Staphylococcus aureus* isolated from retail ready-to-eat foods in Nigeria. Res J Microbiol 2007;2:516–523.

Akbar A, Anil KA. Prevalence and antibiogram study of *Salmonella* and *Staphylococcus aureus* in poultry meat. Asian Pac J Trop Biomed 2013;3:163–168.

Al-Tarazi YH, Albetar MA, Alaboudi AR. Biotyping and enterotoxigenicity of staphylococci isolated from fresh and frozen meat marketed in Jordan. Food Res Int 2009;42: 374–379.

Alvarez-Astorga M, Capita R, Alonso-Calleja C, Moreono B, Garcia-Fernandez MC. Microbiological quality of retail chicken by-products in Spain. Meat Sci 2002;62:45–50.

Argudín MA, Mendoza MC, Rodicio MR. Food poisoning and *Staphylococcus aureus* enterotoxins. Toxins (Basel) 2010; 2:1751–1773.

Arul KT, Saravanan S. Assessment of contamination in chicken meat by food-borne *Staphylococcus aureus.* Int J Res Pure Appl Microbiol 2011;1:59–60.

Batista JEC, Ferreira EL, Nascimento DC, Ventura RF, de Oliveira WLM, Leal NC, Lima-Filho JV. Antimicrobial resistance and detection of the *mec*A gene besides enterotoxin-encoding genes among coagulase-negative staphylococci isolated from clam meat of *Anomalocardia brasiliana*. Foodborne Pathog Dis 2013;10:1044–1049.

Braem G, Stijlemans B, Van Haken W, De Vliegher S, De Vuyst L, Leroy F. Antibacterial activities of coagulase-negative staphylococci from bovine teat apex skin and their inhibitory effect on mastitis-related pathogens. J Appl Microbiol 2014;116:1084–1093.

Citak S, Duman T. *Staphylococcus aureus* and coagulase-negative *Staphylococcus* from raw chicken samples in Turkey: Prevalence and antimicrobial resistance. J Food Agri Environ 2011;9:156–158.

[CLSI] Clinical and Laboratory Standards Institute. *Performance Standards for Antimicrobial Susceptibility Testing. 15th Informational Supplement*. CLSI/NCCLS document. Wayne, PA: CLSI, 2012.

de Medeiros ES, França CA, Krewer CC, Peixoto RM, Júnior AF, Cavalcante MB, da Costa MM, Mota RA. Antimicrobial resistance of *Staphylococcus* spp. isolates from cases of mastitis in buffalo in Brazil. J Vet Diag Invest 2011;23:793–796.

Doyle ME, Hartmann FA, Lee Wong AC. Methicillin-resistant staphylococci: Implications for our food supply? Anim Health Res Rev 2012;13:157–180.

[EC] European Commission. In order to evaluate the official controls related to slaughter and processing of fresh meat, in particular fresh ovine and equine meat. Final report of an audit carried out in Spain from 03 to 13 May 2011, Health and Consumers Directorate-General, DG (SANCO) 2011–6021—MR FINAL.

[EFSA] European Food Safety Authority. ECDC (European Centre for Disease Prevention and Control). The European Union Summary Report on Trends and Sources of Zoonoses, Zoonotic Agents and Food-borne Outbreaks in 2011. EFSA J 2013;11:3129.

EI-Jakee J, Marouf SA, Ata NS, Abdel-Rahman EH, Abd El-Moez SI, Samy WE, El-Sayed AA. Rapid method for Detection of *Staphylococcus aureus* Enterotoxins in Food. Global Veterinaria 2013;11:335–341.

ElNaggar A, Bedier M, Mubarak R. GCP/INT/955/CAN Urban and peri-urban agriculture: Towards better understanding of low-income producers' organizations. Cairo Case Study Report, FAO, IDRC MALR-AERI, UPA-Cairo Case Study Final report—AERI, Egypt, October, 2006.

Euzéby JP. List of Bacterial Names with Standing in Nomenclature. 2014. Available at: http://www.bacterio.net, accessed February 12, 2015.

[FDA] U.S. Food and Drug Administration. *Staphylococcus aureus*: Foodborne pathogenic microorganisms and natural toxins handbook. U.S. Department of Health and Human Services, 2009.

Hassan MK. Promising future for the Egyptian poultry industry. VIV EUROPE, May 2014.

Heo HJ, Ku BK, Bae DH, Park CK, Lee YJ. Antimicrobial resistance of *Staphylococcus aureus* isolated from domestic and imported raw meat in Korea. Korean J Vet Res 2008;48: 75–81.

Jacob M. Safe Food Handling: A Training Guide for Managers of Food Service Establishments. World Health Organization, WHO Library Cataloguing Publication Data, 1989, ISBN 9241542454 (NLM Classification: WA 701).

Kader AA, Yahia EM. Proceedings Expert Consultation Meeting on the Status and Challenges of the Cold Chain for Food Handling in the Middle East and North Africa (MENA) Region Cairo, Egypt 5–7 July 2011, Food and Agriculture Organization of the United Nations Regional Office for the Near East Cairo, Egypt, May 2012.

Kitai S, Shimizu A, Kawano J, Sato E, Nakano C, Kitagawa H, Fujio K, Matsumura K, Yasuda R, Inamoto T. Prevalence and characterization of *Staphylococcus aureus* and enterotoxigenic *Staphylococcus aureus* in retail raw chicken meat throughout Japan. J Vet Med Sci 2005;67:269–274.

Lim SK, Nam HM, Park HJ, Lee HS, Choi MJ, Jung SC, Lee JY, Kim YC, Song SW, Wee SH. Prevalence and characterization of methicillin-resistant *Staphylococcus aureus* in raw meat in Korea. J Microbiol Biotechnol 2010;20:775–778.

Martins PD, de Almeida TT, Basso AP, de Moura TM, Frazzon J, Tondo EC, Frazzon AP. Coagulase-positive staphylococci isolated from chicken meat: Pathogenic potential and vancomycin resistance. Foodborne Pathog Dis 2013;10:771–776.

McEntire J. Bacteria Associated with Foodborne Diseases. Scientific Status Summaries, Institute of Food Technologists, Chicago, IL, August 2004.

Normanno G, La Salandra G, Dambrosio A, Quaglia NC, Corrente M, Parisi A, Santagada G, Firinu A, Crisetti E, Celano GV. Occurrence, characterization and antimicrobial resistance of enterotoxigenic *Staphylococcus aureus* isolated from meat and dairy products. Int J Food Microbiol 2007; 115:290–296.

[OIE] World Organization for Animal Health. Terrestrial Animal Health Code, 2014; Chapter 6.2, Control of biological hazards of animal health and public health importance through ante- and post-mortem meat inspection, Article 6.2.3.

Podkowik M, Bystroń J, Bania J. Genotypes, antibiotic resistance, and virulence factors of staphylococci from ready-to-eat food. Foodborne Pathog Dis 2012;9:91–93.

Rall VLM, Sforcin JM, de Deus MFR, de Sousa DC, Camargo CH, Godinho NC, Galindo LA, Soares TCS, Arau'jo JP Jr. Polymerase chain reaction detection of enterotoxins genes in coagulase-negative staphylococci isolated from Brazilian Minas cheese. Foodborne Pathog Dis 2010;7:1121–1123.

Rogers KL, Fey PD, Rupp ME. Coagulase-negative staphylococcal infections. Infect Dis Clin North Am 2009;23:73–98.

Thorberg BM, Brandstrom B. Evaluation of two commercial systems and a new identification scheme based on solid substrates for identifying coagulase-negative staphylococci from bovine mastitis. J Vet Med B, Infect Dis Vet Public Health 2000;47:683–691.

Todd ECD, Greig JD, Bartleson CA, Michaels BS. Outbreaks where food workers have been implicated in the spread of foodborne disease: Part 5. Sources of contamination and pathogen excretion from infected persons. J Food Prot 2008; 71:2582–2595.

[USDA] United States Department of Agriculture. Foreign Agricultural Service. Egypt. Livestock and Products Annual. Political and Economic Stability Will Influence Beef Consumption. Gain Report 2014. Global Agricultural Information Network.

van Loo IHM, Diederen BMW, Savelkoul PHM, Woudenberg JHC, Roosendaal R, van Belkum A, Toom NL, Verhulst C, van Keulen PHJ, Kluytmans JAJW. Methicillin-resistant *Staphylococcus aureus* in meat products, The Netherlands. Emerg Infect Dis 2007;13:1753–1755.

Wang X, Tao X, Xia X, Yang B, Xi M, Meng J, Zhang J, Xu B. *Staphylococcus aureus* and methicillin-resistant *Staphylococcus aureus* in retail raw chicken in China. Food Control 2013;29:103–106.

Waters AE, Contente-Cuomo T, Buchhagen J, Liu CM, Watson L, Pearce K, Foster JT, Bowers J, Driebe EM, Engelthaler DM, Keim PS, Price LB. Multidrug-resistant *Staphylococcus aureus* in US meat and poultry. Clin Infect Dis 2011;52: 1227–1230.

Wise RE. Combating antimicrobial resistance: The role of the Specialist Advisory Committee on Antimicrobial Resistance. J Antimicrob Chemother 2007;60(Suppl 1):i5–i7.

Zhang K, Sparling J, Chow BL, Elsayed S, Hussain Z, Church DL, Gregson DB, Louie T, Conly JM. New quadriplex PCR assay for detection of methicillin and mupirocin resistance and simultaneous discrimination of *Staphylococcus aureus* from coagulase-negative staphylococci. J Clin Microbiol 2004;42:4947–4955.

Address correspondence to:
Kamelia M. Osman, PhD
Department of Microbiology
Faculty of Veterinary Medicine
Cairo University
P.O. Box 12211
Cairo, Egypt

E-mail: kamelia-osman@hotmail.com