



# Prevalence and Antimicrobial Resistance of *Staphylococcus aureus*, *Salmonella* and *Escherichia coli* Isolated from Poultry Meat in Tandojam, Hyderabad, Pakistan

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## ABSTRACT

Poultry meat is mostly consumed by people due to its good quality of protein and presence of all essential amino acids. In the present study, 100 poultry meat samples were randomly collected from district Hyderabad and cultured on selective media for the isolation and identification; mannitol salt agar for *Staphylococcus aureus* (*Staph. aureus*), Salmonella Shigella agar and brilliant green agar for *Salmonella* and MacConkey agar for *Escherichia coli* (*E. coli*). Furthermore, biochemical tests were performed for the confirmation of bacterial species. Overall, 19%, 35% and 56% prevalence were found for *Staph. aureus*, *Salmonella* and *E. coli*, respectively. Antimicrobial resistance of fourteen antibiotics (gentamycin, erythromycin, penicillin, ampicillin, vancomycin, neomycin, tetracycline, oxytetracycline, doxycycline, bacitracin, cephalothin, norfloxacin, streptomycin and kanamycin) were performed by disk diffusion method against *Staph. aureus*, *Salmonella* and *E. coli* showed resistance against all drugs. However, *Staph. aureus* showed high resistance to norfloxacin 84%, penicillin and ampicillin 78%, tetracycline, oxytetracycline and kanamycin 73%, bacitracin, doxycycline and vancomycin 68%, cephalothin 63%, neomycin 36%, erythromycin and gentamycin 31% and streptomycin 15%. *Salmonella* showed high resistance to ampicillin 94%, penicillin 91%, oxytetracycline 88%, bacitracin and neomycin 85%, doxycycline and tetracycline 82%, erythromycin, gentamycin and cephalothin 80%, kanamycin 74%, vancomycin 68%, norfloxacin and streptomycin 62%. Whereas, *E. coli* showed high resistance to penicillin and ampicillin 87%, norfloxacin 85%, tetracycline and doxycycline 82%, neomycin and streptomycin 80%, doxycycline 78%, vancomycin 76%, kanamycin 75% and gentamycin 8%. In conclusion, high prevalence of *Staph. aureus*, *Salmonella* and *E. coli* were observed in poultry meat. The bacteria were found to be highly resistant to penicillin and ampicillin. Proper use of antibiotics is recommended to control the emergence of drug resistance.

### Article Information

Received 03 August 2022

Revised 25 May 2023

Accepted 16 June 2023

Available online 08 September 2023 (early access)

### Authors' Contribution

SS, DHK, SHA and ARN conceived and designed the experiments. SS and DHK performed the experiments. MSK, MHM, AAS, AC, AK, HAK, MIP and MH analyzed the data. SS and DHK wrote the paper.

### Key words

Antimicrobial resistance, Poultry, Meat, *Staphylococcus aureus*, *Salmonella*, *Escherichia coli*

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0030-9923/2023/0001-0001 \$ 9.00/0



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## INTRODUCTION

The unhygienic foodstuff is the major cause for the transmission of pathogenic microbes. In developing countries mostly, the mortality and morbidity occur due to the pathogenic bacteria (Gunasegaran *et al.*, 2011). A high quality of protein source is fulfilled by poultry meat to the humans due to its sensorial characteristics.

Mostly the diseases occurred due to the consumption of unhygienic meat containing pathogenic bacteria meat such as *Salmonella* spp., and *Staphylococcus aureus* (European Food Safety Authority, 2009). The World Health Organization (WHO), and Food and Agriculture Organization (FAO) have reported high risk of *Salmonella* and *Campylobacter* present in broiler meat (WHO, 1986, FAO, 2014). Chicken meat is contaminated by various microorganisms during slaughtering processing, environment and by handling equipment. Many of these bacteria are not destroyed during meat processing and storage. Consequently, bacterial infections are present in chicken meat which includes pathogenic species, causing severe gastrointestinal problems in humans (Authority, 2016). Chicken meat is one of the most well-known food worldwide as it contains numerous basic amino acids, minerals such as sodium, potassium, calcium, iron, phosphorous and vitamins like, B12 and niacin needed for life maintenance and development (FAO, 2014). Poultry meat is an ideal vehicle for bacterial development and known to hold countless microbes that are pathogenic to humans. This commonly happens in low disinfection levels, and may pose health concern to the customer if the meat isn't treated in a protected way (Zakaria, 2005).

*Staph. aureus* infections are associated with nosocomial infections (Kadariya *et al.*, 2014). As a major foodborne pathogen it also causes the gastrointestinal disorders. In United States of America, total 241,000 foodborne cases were recorded per year caused by *Staph. aureus* (Scallan *et al.*, 2011). Chicken meat is the key source of spreading staphylococcal foodborne diseases (Hanson *et al.*, 2011). Generally, it has been reported in different countries that uncooked fresh and frozen chicken and turkey meat were contaminated by *Staph. aureus* (Waldroup, 1996). In China and Japan, raw chicken meat and their byproducts are being eaten by the people at high rate. Therefore, it is necessary to observe the actual contamination of enterotoxigenic *Staph. aureus* in raw chicken meat (Shimizu and Horie, 1999; Shimizu *et al.*, 1991; Jiang *et al.*, 2001). *Salmonella* species are causing foodborne diseases which has become major public health problem in Thailand. A high percentage of *Salmonella* infection was recorded in pigs, cattle, poultry and humans. Usually, *Salmonella* cause infections in humans through unhygienic food and mostly by consuming animal byproducts. The clinical signs of salmonellosis are nausea, vomiting, cramps, diarrhea and bacteremia may occur in severe cases. Thai food during a survey in 1993-1996 suggested that *S. enteritidis* and *S. anatum* were major contaminants found in frozen chicken and ready to eat meat (Boonmar *et al.*, 1998). *S. enteritidis* found in chicken meat, caused salmonellosis in humans reported

by *Salmonella* and *Shigella* Center of Thailand (Sakai and Chalermchaikit, 1996).

*Escherichia coli* is normally present in the intestinal microflora of animals and humans. *E. coli* are beneficial bacteria but some strains cause diseases in humans, mammals and birds (Fairbrother and Gyeleka, 1994; Kaper *et al.*, 2004). Pathogenic strains of *E. coli* are divided into two forms on the basis of producing intestinal and extra intestinal infection. Intestinal infection includes mild to severe diarrhea caused by enterotoxigenic or Enterohaemorrhagic *E. coli*, emerged from a hemolytic uremic syndrome (Kaper *et al.*, 2004). Extra intestinal *E. coli* producing infection in both animals and humans like urinary tract infection, meningitis and septicemia. Uro pathogenic *E. coli* may become colonize into urinary tract hence, cystitis and polynephritis may occur which leads to urosepsis (Kaper *et al.*, 2004).

Resistance of antimicrobial drugs has become serious health problem throughout the world. The resistance has occurred due to the misuse of drugs as a growth promoter in animals and birds (Normanno *et al.*, 2007). The administration of antibiotics in food producing animals leads to bacterial resistance in humans via consuming food (Demirturk and Demirdal, 2004). More than 50 years antimicrobial drugs have been used in animal feed to enhance their activity and disease control. A prolonged usage of drugs in animal feed is considered as a major feature for drug resistance (Robredo *et al.*, 2000; Lange and Brokking, 2005). Due to the consumption of raw chicken and turkey meat in most of the countries the resistant bacterial strains may transfer to the humans via food (Duman, 2007; Irlinger, 2008). The isolation of enterococci, *Staph. aureus*, Staphylococci and coagulase negative bacteria indicated high usage of antibiotics were used in chickens to control infections hence, the more antimicrobial resistance has occurred (De Boer *et al.*, 2009; Kasimoglu *et al.*, 2010). *Salmonella* infection may transfer to human from eating unhygienic meat (White *et al.*, 2001). It has been recommended that resistant strains of *Salmonella* can cause serious diseases because of the presence of virulence factors (Verma *et al.*, 2005).

The pharmaceutical industries of Germany, United Kingdom and France have made wonderful successes by introducing new antimicrobial drugs every three years. In the 21<sup>st</sup> century, antibiotic resistance was the most severe problem of the world. Few enteric human pathogens have become resistant due to the transmission of resistance genes or bacteria from animals to people through food chain (Barton, 2000). Food plays a significant role in the transmission of antibiotic resistance in terms of antibiotic residues or transfer of resistant genes from food microflora to pathogenic bacteria (Pereira *et al.*, 2009). Present study

evaluated the presence of potential foodborne pathogens such as *Staph. aureus*, *Salmonella* and *E. coli* in poultry meat and furthermore to evaluate the antimicrobial resistance pattern of these pathogens.

## MATERIALS AND METHODS

### Collection of meat samples

One hundred fresh chicken meat samples were collected aseptically from local shops of Tandojam and District Hyderabad in polythene bags. The samples were transported in an ice box to the Department of Veterinary Microbiology, Faculty of Animal Husbandry and Veterinary Sciences, Sindh Agriculture University and Central Veterinary Diagnostic Lab Tandojam and frozen at 4°C till examined.

### Antibiogram of bacterial isolates

To evaluate the susceptibility of isolated bacteria fourteen antibiotics of different groups were used, which include; gentamycin, oxytetracycline, doxycycline, kanamycin, tetracycline, ampicillin, streptomycin, norfloxacin, neomycin, penicillin, vancomycin, bacitracin, erythromycin, cephalothin. A pure culture colony was picked up and dispensed into the normal saline solution. The solution was mixed well to confirm that no dense material was evident. Clean swab was taken and immersed into the broth culture. Sterilized Mueller-Hinton agar plates were taken; swab was streaked on it and dried for 5 minutes. Seven different antibiotic discs were placed on the surface of the agar with the help of sterilized forceps. Cultured plates were overturned and incubated for 24 hours at 37° C. After incubation, inhibitory zones were measured by a metric ruler according to the Clinical and Laboratory Standards Institute (CLSI).

## RESULTS AND DISCUSSION

Table I shows that out of a total of 100 meat samples from chicken meat were examined, 19 (19%) samples were found positive for *Staph. aureus*, 35 (35%) samples were found positive for *Salmonella* and 56 (56%) samples were found to be positive for *E. coli*. Similar results were recorded by Madhai *et al.* (2014) in Iran who recorded 6.42% prevalence in chicken meat products, while Akbar and Anal (2013) recorded 18.18% prevalence in Thailand. Pesavento *et al.* (2007) stated 28.6 % prevalence in Italy. Bhargava *et al.* (2011) recorded 25% prevalence in United States and 17.8% in Iowa. Hansona *et al.* (2011) recorded 42.1% prevalence in Oklahoma. Abdalrahman *et al.* (2015) also recorded 41% prevalence in USA. Our results are not in agreement with Gundogan *et al.* (2005)

who reported 43.3% prevalence in Turkey. During present study 35 (35%) prevalence of *Salmonella* was observed. Similar investigation was done by Minami *et al.* (2010) recorded 25% of prevalence in chicken meat during the study in Thailand. Seza and Ayla (2010) reported 29.3% prevalence of *Salmonella* in poultry meat. Bundesinstitut für Risikobewertung (2009) reported 19.9% of prevalence of *Salmonella* from chicken meat. Bundesinstitut für Risikobewertung (2009) recorded the 17.4% prevalence of *Salmonella* in chicken meat. Boonmar *et al.* (1998) reported 72% of prevalence of *Salmonella* in chicken meat. Our results are not in agreement with Ellerbroek *et al.* (2010) who reported 13% prevalence of *Salmonella* in chicken carcass in Bhutan. During present study 56 (56%) prevalence was reported for *Escherichia coli* infection in poultry meat. These results are agreed to some extent with the study of Abd El Tawab (2014) who isolated *E. coli* at a percentage of 38%. Nehal (2009) and Mahajan (1994) reported the incidence of *E. coli* 41% to 60.9% in chickens.

**Table I. Prevalence of *Staph. aureus*, *Salmonella* and *E. coli* isolated from poultry meat of Tandojam.**

Bacterial isolates	No. of positive samples
<i>Staphylococcus aureus</i>	19 (19%)
<i>Salmonella</i>	35 (35%)
<i>E. coli</i>	56 (56%)

Table II show the efficacy of fourteen antibiotics against *Staph. aureus*, *Salmonella* and *E. coli*. *Staph. aureus* showed 15% resistance to streptomycin, 31% resistance to gentamycin and erythromycin, 36% resistance to neomycin, 63% resistance to cephalothin, 68% resistance to doxycycline, vancomycin and bacitracin, 73% resistance to oxytetracycline, tetracycline and kanamycin, 78% resistance to ampicillin and penicillin and 84% resistance to norfloxacin.

*Salmonella* showed 62% resistance against streptomycin and norfloxacin, 68% resistance to vancomycin, 74% resistance to kanamycin, 80% resistance to gentamycin, cephalothin and erythromycin, 82% resistance to tetracycline and doxycycline, 85% resistance to neomycin and bacitracin, 88% resistance to oxytetracycline, 91% resistance to penicillin and 94% resistance to ampicillin.

*E. coli* showed 8% resistance to gentamycin, 75% resistance to kanamycin, 76% resistance to vancomycin, 78% resistance to doxycycline, 80% resistance streptomycin, neomycin, bacitracin and erythromycin, 82% resistance to doxycycline and tetracycline, 85% resistance to norfloxacin, 87% resistance to penicillin and ampicillin.

**Table II. Antimicrobial resistance of *Staph. aureus*, *Salmonella* and *E. coli* isolated from poultry meat from Tandojam.**

Antimicrobial agent ( $\mu$ g)	<i>Staph. aureus</i> (n=19)	<i>Salmonella</i> (n=35)	<i>E. coli</i> (n=56)
Gentamycin (30)	6 (31%)	28 (80%)	5 (8%)
Oxytetracycline (30)	14 (73%)	31 (88%)	46 (82%)
Doxycycline (30)	13 (68%)	29 (82%)	44 (78%)
Kanamycin (30)	14 (73%)	26 (74%)	42 (75%)
Tetracycline (30)	14 (73%)	29 (82%)	46 (82%)
Ampicillin (10)	15 (78%)	33 (94%)	49 (87%)
Streptomycin (10)	3 (15%)	22 (62%)	45 (80%)
Norfloracin (10)	16 (84%)	22 (62%)	48 (85%)
Neomycin (10)	7 (36%)	30 (85%)	45 (80%)
Cephalothin (30)	12 (63%)	28 (80%)	46 (82%)
Penicillin (10)	15 (78%)	32 (91%)	49 (87%)
Vancomycin (30)	13 (68%)	24 (68%)	43 (76%)
Bacitracin (10)	13 (68%)	30 (85%)	45 (80%)
Erythromycin (15)	6 (31%)	28 (80%)	45 (80%)

*Staphylococcus* was found highly resistant to norfloracin (84%), penicillin, ampicillin (78%), oxytetracycline, kanamycin, oxytetracycline (73%), doxycycline, vancomycin, bacitracin (68%), cephalothin (63%), while mildly resistant to erythromycin, gentamycin (31%), neomycin (36%) and streptomycin (15%). Our results are in agreement with other authors. *Staph. aureus* showed resistance to penicillin (Laxminarayan *et al.*, 2013). Multi-drug resistance was detected in 22.2% of isolates, while maximum resistance was found against oxytetracycline (43.1%) and penicillin (23.8%). Oxytetracycline showed highest resistance among tested antibiotics in Thailand (Akbar and Anal, 2013).

*Salmonella* was found highly resistant to ampicillin 94%, penicillin 91%, oxytetracycline 88%, neomycin 85%, doxycycline, tetracycline 82%, gentamycin, erythromycin, cephalothin 80%, kanamycin 74%, vancomycin 68% while mild resistance to streptomycin and norfloracin 62%. Our results agree with Akbar and Anal (2013), who reported 73% resistance against tetracycline, 18.48% resistance to chloramphenicol, 36% to nalidixic acid and 27% resistant to ciprofloxacin. Odoch *et al.* (2017) reported 50% resistance to ciprofloxacin, 5.1% to tetracycline and 5.1% to chloramphenicol.

In our study *E. coli* was found highly resistant to ampicillin, penicillin 87%, norfloracin 85%, oxytetracycline, tetracycline, cephalothin 82%,

streptomycin, neomycin, bacitracin, erythromycin 80%, doxycycline 78%, vancomycin 76%, 75% kanamycin, while mildly resistant 8% to gentamycin. Our results are in agreement with other authors. Adeyanju and Ishola (2014) reported 4.9% prevalence of *E. coli* in Korea and 43% in Nigeria, while Joshi *et al.* (2019) 8.89% prevalence rate. Apun *et al.* (2008) isolated *E. coli* from broiler chicken in Malaysia and reported *E. coli* resistance to ampicillin, tetracycline and gentamicin with 11-95%. Rahman *et al.* (2008) recovered isolates of *E. coli* from poultry during his research work in Bangladesh and found *E. coli* resistance against chloramphenicol, ampicillin, ciprofloxacin, tetracycline and streptomycin in 37-87.5% cases; and 50-66.6% strains were highly sensitive to chloramphenicol and gentamicin 66-100%. While, Islam *et al.* (2008) reported *E. coli* resistance to tetracycline, penicillin, erythromycin and chloramphenicol. Tricia *et al.* (2006) reported 43% *E. coli* resistance against ampicillin.

## CONCLUSION

Present study evaluated the prevalence of *Staph. aureus*, *E. coli* and *Salmonella* found in food chain. The chick meat samples showed 19% resistance to *Staph. aureus*, 35% to *Salmonella* and 56% *E. coli*. *Staph. aureus* was highly resistant to norfloracin and penicillin, *Salmonella* was highly resistant to ampicillin and penicillin while *E. coli* was highly resistant to penicillin and ampicillin. In conclusion, *Staph. aureus*, *Salmonella* and *E. coli* are present as a foodborne pathogen in poultry meat. These pathogens are causing variety of diseases in humans via food chain.

## ACKNOWLEDGEMENTS

The authors are highly grateful to the Central Veterinary Diagnostic Laboratory, Tandojam, Directorate of Veterinary Research and Diagnosis, Government of Sindh, Pakistan

### Funding

The research was accomplished by utilizing routine working budget of Central Veterinary Diagnostic Laboratory, Tandojam, Sindh, Pakistan.

### IRB approval

The research project was approved by the Directorate of Advanced Studies, Sindh Agriculture University, Tandojam, Pakistan.

### Ethics statement

The study was conducted in line with the recommendations of Ethical Committee vide No. DAS 2674/ of 2019 of Director of Advanced.

#### Statement of conflict of interest

The authors have declared no conflict of interest.

### REFERENCES

- Abd El-Tawab, Ashraf, A., Ahmed, A.A. Maarouf, Samir, A. Abd El-Al, Fatma, El-Hofy, I. and Emad, El-Mougy, E.A., 2014. Detection of some virulence genes of avian pathogenic *E. coli* by polymerase chain reaction. *Benha Vet. med. J.*, **26**: 159-176.
- Abdallahman, L.S., Stanley, A., Wells, H. and Fakhr, M.K., 2015. Isolation, virulence, and antimicrobial resistance of methicillin-resistant *Staphylococcus aureus* (MRSA) and methicillin sensitive *Staphylococcus aureus* (MSSA) strains from Oklahoma retail poultry meats. *Int. J. environ. Res. Publ. Hlth.*, **12**: 6148-6161. <https://doi.org/10.3390/ijerph120606148>
- Adeyanju, G.T. and Ishola, O., 2014. *Salmonella* and *Escherichia coli* contamination of poultry meat from a processing plant and retail markets in Ibadan, Oyo State, Nigeria. *Springer Plus*, **3**: 139. <https://doi.org/10.1186/2193-1801-3-139>
- Akbar, A. and Anal, A.K., 2013. Prevalence and antibiogram study of *Salmonella* and *Staphylococcus aureus* in poultry meat. *Asian Pac. J. trop. Biomed.*, **3**: 163-168. [https://doi.org/10.1016/S2221-1691\(13\)60043-X](https://doi.org/10.1016/S2221-1691(13)60043-X)
- Apun, K., Chong, Y.L., Abdullah, M.T. and Micky, V., 2008. Antimicrobial susceptibilities of *Escherichia coli* isolates from food animals and wildlife animals in Sarawak, East Malaysia. *Asian J. Anim. Vet. Adv.*, **3**: 409-416. <https://doi.org/10.3923/ajava.2008.409.416>
- Authority, E.F.S., 2016. The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2015. *EFSA J.*, **14**: 4634. <https://doi.org/10.2903/j.efsa.2016.4634>
- Bangtrakulnonth, A., Pornreongwong, S. and Pulsrikarn, C., 1991. *Salmonella* serovars from humans and other sources in Thailand, 1993-2002. *Emerg. Infect. Dis.*, **10**: 131-135. <https://doi.org/10.3201/eid1001.02-0781>
- Butzler, J. and Oosterom, J., 1997. Campylobacter: Pathogenicity and significance in foods. *Int. J. Fd. Microbiol.*, **12**: 1-8. [https://doi.org/10.1016/0168-1605\(91\)90043-O](https://doi.org/10.1016/0168-1605(91)90043-O)
- Barton, M.D., 2000. Antibiotics use in animal feed and its impact on human health. *Nutr. Res. Rev.*, **13**: 1-22. <https://doi.org/10.1079/095442200108729106>
- Bhargava, K., Wang, X., Donabedian, S., Zervos, M., Da Rocha, L. and Zhang, Y., 2011. Methicillin-resistant *Staphylococcus aureus* in retail meat, Detroit, Michigan, USA. *Emerg. Infect. Dis.*, **17**: 1135-1137. <https://doi.org/10.3201/eid1706.101905>
- Bodhidatta, L., Vithayasai, N., Eimpokalarp, B., Pitarangsi, C., Serichantalergs, O. and Isenbarger, D.W., 2002. Bacterial enteric pathogens in children with acute dysentery in Thailand: Increasing importance of quinolone resistant *Campylobacter*. *S. Asian J. trop. Med. Publ. Hlth.*, **33**: 752-757.
- Boonmar, S., Bangtrakulnonth, A., Pornrunangwong, S., Marnrim, N., Kaneko, K. and Ogawa, M., 1998. *Salmonella* in broiler chickens in Thailand with special reference to contamination of retail meat with *Salmonella enteritidis*. *J. Vet. med. Sci.*, **60**: 1233-1236. <https://doi.org/10.1292/jvms.60.1233>
- Bundesinstitut für Risikobewertung, 2009. *Grundlagenstudie zum Vorkommen von Campylobacter spp. and Salmonella spp. Schlachtkörpern von Masthähnchen vorgelegt*. Stellungnahme Nr. 010/2010 des BfR vom 16.
- De Boer, E., Zwartkruis-Nahuis, J.T.M., Wit, B., Huijsdens, X.W., Neeling, A.J., Bosch, T. and Van Oosterom, R.A.A., 2009. Prevalence of methicillin-resistant *S. aureus* in meat. *Int. J. Fd Microbiol.*, **134**: 52-56. <https://doi.org/10.1016/j.ijfoodmicro.2008.12.007>
- Demirtürk, N. and Demirdal, T., 2004. Antibiyotiklerde Direnç Sorunu. *Kocatepe Tıp Dergisi*, **5**: 17-21.
- Duman, T., 2007. *Tavuk Karkaslarından İzole Edilen Staphylococcus'ların Virülans Faktörleri ve Antibiyotik Dirençliliği*. Gazi Üniversitesi Fen Bilimleri Enstitüsü Yüksek Lisans Tezi.
- Ellerbroek, L., Narapati, D., Phu Tai, N., Poosaran, N., Pinthong, R., Sirimalaisuwana, A., Tshering, P., Fries, R., Zessin, K.H., Baumann, M. and Schroeter, A., 2010. Antibiotic resistance in *Salmonella* isolates from imported chicken carcasses in Bhutan and from pig carcasses in Vietnam. *J. Fd. Prot.*, **73**: 376-379. <https://doi.org/10.4315/0362-028X-73.2.376>
- European Food Safety Authority, 2009. The community summary report on trends and sources of zoonosis and zoonotic agents in the European Union in 2007. *EFSA J.*, **223**. Available: [http://www.efsa.europa.eu/EFSA/efsa\\_locale1178620753812\\_1211902269834.htm](http://www.efsa.europa.eu/EFSA/efsa_locale1178620753812_1211902269834.htm), <https://doi.org/10.2903/j.efsa.2009.223r>
- Fairbrother, J.M. and Ngeleka, M., 1994. Extraintestinal *Escherichia coli* infections in pigs. In: *Escherichia*

- coli* in domestic animals and humans (ed. C.L. Gyles), CAB inter. Wallingford, pp. 221–236.
- Food and Agriculture Organization (FAO), 2014. *The role of poultry in human nutrition*. available at: [www.FAO.org/docrp/013/a1713e/a1713e00](http://www.FAO.org/docrp/013/a1713e/a1713e00).
- Gunasegaran, T., Rathinam, X., Kasi, M., Sathasivam, K., Sreenivasan, S. and Subramaniam, S., 2011. Isolation and identification of *Salmonella* from curry samples and its sensitivity to commercial antibiotics and aqueous extracts of *Camelia sinensis* (L.) and *Trachyspermum ammi* (L.). *Asian Pac. J. trop. Biomed.*, **1**: 266-269. [https://doi.org/10.1016/S2221-1691\(11\)60040-3](https://doi.org/10.1016/S2221-1691(11)60040-3)
- Gundogan, N., Citak, S., Yucel, N. and Devren, A., 2005. A note on the incidence and antibiotic resistance of *Staphylococcus aureus* isolated from meat and chicken samples. *Meat Sci.*, **69**: 807–810. <https://doi.org/10.1016/j.meatsci.2004.10.011>
- Hanson, B., Dressler, A., Harper, A., Scheibel, R., Wardyn, S., Roberts, L., Kroeger, J. and Smith, T., 2011. Prevalence of *Staphylococcus aureus* and methicillin resistant *Staphylococcus aureus* (MRSA) on retail meat in Iowa. *J. Infect. Publ. Hlth.*, **4**: 169-174. <https://doi.org/10.1016/j.jiph.2011.06.001>
- Irlinger, F., 2008. Safety assessment of dairy microorganisms: Coagulase negative Staphylococci. *Int. J. Fd. Microbiol.*, **126**: 302–310. <https://doi.org/10.1016/j.ijfoodmicro.2007.08.016>
- Islam, M.J., Sultana, S., Das, K.K., Sharmin, N. and Hassan, M.N., 2008. Isolation of plasmid mediated multidrug resistant *E. coli* from poultry. *Int. J. Sustain. Crop Prod.*, **3**: 46-50.
- Jiang, C.M., Liu, P.H., Ding, J.P., Liu, X.G., Hu, D.L. and Shinagawa, K., 2001. Incidence and pollution of enterotoxigenic *Staphylococcus aureus* in milk, meat and fish in China. *Jpn. J. Fd. Microbiol.*, **18**: 43-47.
- Joshi, P.R., Thummeepak, R., Paudel, S., Acharya, M., Pradhan, S., Banjara, M.R., Leungtongkam, U. and Sitthisak, S., 2019. Molecular characterization of colistin-resistant *Escherichia coli* isolated from chickens: first report from Nepal. *Microb. Drug Resist.*, **25**: 846–854. <https://doi.org/10.1089/mdr.2018.0326>
- Kadariya, J., Tara, C.S. and Dipendra, T., 2014. *Staphylococcus aureus* and staphylococcal food-borne disease: An ongoing challenge in public health. *BioMed. Res. Int.*, pp. 1-10. <https://doi.org/10.1155/2014/827965>
- Kaper, J.B., Nataro, J.P. and Mobley, H.L., 2004. Pathogenic *Escherichia coli*. *Nat. Rev. Microb.*, **2**: 123–140. <https://doi.org/10.1038/nrmicro818>
- Kasimoglu-Dogru, A., Gencay, Y.E. and Ayaz, N.D., 2010. Prevalence and antibiotic resistance profiles of *Enterococcus* species in chicken at slaughter level; absence of *vana* and *vanB* genes in *E. faecalis* and *E. faecium*. *Res. Vet. Sci.*, **89**: 153–158. <https://doi.org/10.1016/j.rvsc.2010.02.005>
- Lange, D.L. and Brokking, D.H., 2005. Nutriotics could replace antibiotics in feed. *World Poult.*, **10**: 26–28.
- Laxminarayan, R., Duse, A., Wattal, C., Zaidi, A.K.M., Wertheim, H.F.L. and Sumpradit, N., 2013. Antibiotic resistance: The need for global solutions. *Lancet Infect. Dis.*, **13**: 1057–1098. [https://doi.org/10.1016/S1473-3099\(13\)70318-9](https://doi.org/10.1016/S1473-3099(13)70318-9)
- Madahi, H., Rostami, F., Rahimi, E. and Dehkordi, F.S., 2014. Prevalence of enterotoxigenic *Staphylococcus aureus* isolated from chicken nugget in Iran. *Jundishapur J. Microbiol.*, **7**: 2–6. <https://doi.org/10.5812/jjm.10237>
- Mahajan, N.R., Jindal, and Kulshreshtha, R.C., 1994. Major broiler disease in some parts of Haryana. *Indian J. Anim. Sci.*, **64**: 1118-1122.
- Minami, A., Wanpen, C., Chongsa-Nguan, M., Seksun, S., Shuko, M., Kouichi, T., Makino, S.I. and Kawamoto, K., 2010. Prevalence of foodborne pathogens in open markets and supermarkets in Thailand. *Fd. Contr.*, **21**: 221-226. <https://doi.org/10.1016/j.foodcont.2009.05.011>
- Nehal, A.A.N., 2009. *Diversity and prevalence of Escherichia coli in chickens, environment and related persons*. M.V.Sc. thesis, Fac. Vet. Med.
- Normanno, G., Corrente, M., La Salandra, G., Dambrosio, A., Quaglia, N.C., Parisi, A., Greco, G., Bellacicco, A.L., Virgilio, S. and Celano, G.V., 2007. Methicillin resistant *Staphylococcus aureus* (MRSA) in foods of animal origin product in Italy. *Int. J. Fd. Microbiol.*, **117**: 219–222.
- Odoch, T., Wasteson, W., L'Abée-Lund, T., Muwonge, A., Kankyal, C., Nyakarahuka, L., Tegule, S. and Skjerve, E., 2017. Prevalence, antimicrobial susceptibility and risk factors associated with non-typhoidal *Salmonella* on Ugandan layer hen farms. *BMC Vet. Res.*, **13**: 365. <https://doi.org/10.1186/s12917-017-1291-1>
- Pereira, V., Lopes, C., Castro, A., Silva, J., Gibbs, P. and Teixeira, P., 2009. Characterization for enterotoxin production, virulence factors, and antibiotic susceptibility of *S. aureus* isolates from various foods from Portugal c susceptibility of *S. aureus* isolates from various foods in Portugal. *Fd. Microbiol.*, **26**: 278-282. <https://doi.org/10.1016/j>

- fm.2008.12.008
- Pesavento, G., Ducci, B., Comodo, N. and Lo Nostro, A., 2007. Antimicrobial resistance profile of *Staphylococcus aureus* isolated from raw meat: A research for methicillin resistant *Staphylococcus aureus* (MRSA). *Fd. Contr.*, **18**: 196–200. <https://doi.org/10.1016/j.foodcont.2005.09.013>
- Rahman, M., Rahman, B.M. and Rahman, B., 2008. Antibioqram and plasmid profile analysis of isolated *Escherichia coli* from broiler and layer. *Res. J. Microbiol.*, **3**: 82-90. <https://doi.org/10.3923/jm.2008.82.90>
- Ribot, E.M., Wierzba, R.K., Angulo, F.J. and Barrett, T.J., 2002. *Salmonella enterica* serotype typhimurium DT104 isolated from humans, United States, 1985, 1990, and 1995. *Emerg. Infect. Dis.*, **8**: 387e391. <https://doi.org/10.3201/eid0804.010202>
- Robredo, B., Singh, K.V., Baquero, F., Murray, B.E. and Torres, C., 2000. Vancomycin resistant *enterococci* isolated from animals and food. *Int. J. Fd. Micobiol.*, **54**: 197–204. [https://doi.org/10.1016/S0168-1605\(99\)00195-6](https://doi.org/10.1016/S0168-1605(99)00195-6)
- Sakai, T. and Chalermchaikit, T., 1996. The major sources of *Salmonella enteritidis* in Thailand. *Int. J. Fd. Microbiol.*, **31**: 173-180. [https://doi.org/10.1016/0168-1605\(96\)00979-8](https://doi.org/10.1016/0168-1605(96)00979-8)
- Scallan, E., Hoekstra, R.M., Angulo, F.J., Tauxe, R.V., Widdowson, M.A., Roy, S.L., Jones, J.L. and Griffin, P.M., 2011. Foodborne illness acquired in the United States major pathogens. *Emerg. Infect. Dis.*, **17**. <https://doi.org/10.3201/eid1701.P11101>
- Seza, A. and Ayla, E., 2010. Occurrence and antibiotic resistance profiles of *Salmonella* species in retail meat products. *J. Fd. Prot.*, **73**: 1613-1617. <https://doi.org/10.4315/0362-028X-73.9.1613>
- Shimizu, A. and Horie, 1999. *Staphylococcus aureus* contamination of commercial raw chicken and pork at a supermarket and epidemiological investigation of the isolates by using pulsed-field gel electrophoresis. *Jpn. J. Fd. Microbiol.*, pp. 275-161.
- Shimizu, A., Kawano, J., Yamamoto, C., Kakutani, O., Anazai, T. and Kamada, M., 1997. Genetic analysis of equine methicillin-resistant staphylococcus aureus by pulsed-field gel electrophoresis. *J. Vet. med. Sci.*, **59**: 935-937. <https://doi.org/10.1292/jvms.59.935>
- Shimizu, A., Ozaki, J., Kawano, J. and Kimura, S., 1991. Isolation and characterization of *Staphylococcus aureus* from raw fish and meat. *Jpn. J. Fd. Microbiol.*, **8**: 135-141.
- Tricia, D.M., McLaughlin, W. and Brown, P.D., 2006. Antimicrobial resistance of *Escherichia coli* isolates from broiler chickens and humans. *BMC Vet. Res.*, **2**: 7. <https://doi.org/10.1186/1746-6148-2-7>
- Verma, J.K., Greene, K.D., Ovitt, J., Barrett, T.J., Medalla, F. and Angulo, F.J., 2005. Hospitalization and antimicrobial resistance in *Salmonella* outbreaks, 1984e2002. *Emerg. Infect. Dis.*, **11**: 943e946. <https://doi.org/10.3201/eid1106.041231>
- Waldroup, A.L., 1996. Contamination of raw poultry with pathogens. *World's Poult. Sci. J.*, **52**; 7-25. <https://doi.org/10.1079/WPS19960002>
- White, D.W., Zhao, S., Sudler, R., Ayers, S., Friedman, S., Chen, S., McDermott, P.F., McDermott, S., Wagner, D.D. and Meng, J., 2001. The isolation of antibiotic-resistant *Salmonella* from retail ground meats. *N. Engl. J. Med.*, **345**: 1147e1153. <https://doi.org/10.1056/NEJMoa010315>
- World Health Organisation (WHO), 1986. *Prevention and control of foodborne Salmonellosis through the application of the hazard analysis critical control point system*. Report of an International Commission on Microbiological Specification for Foods (ICMSF), WHO/CDS/ VPH/86. 65, Geneva.
- Zakaria, I.M., 2005. *Anaerobic bacteria in chicken meat products*. Thesis, Master of Veterinary Medicine (Meat Hygiene), Benha University, Egypt.