Frequency of Extended Spectrum Beta Lactamase Producing *Escherichia coli* in Fresh and Frozen Meat

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**ABSTRACT**

A cross sectional study was performed to determine the frequency of *Escherichia coli* in fresh and frozen meat samples followed by antimicrobial resistance profiling and to detect different extended spectrum beta lactamas (ESBLs) genes. A total of 100 samples of fresh and frozen meat (n=50 each) were collected from different butcher shops and supermarkets. Equal numbers of specimens were collected from chicken and mutton. Samples were processed for isolation and identification of *E. coli* by standard microbiological, biochemical and molecular characterization. The resistance pattern was detected by Kirby-Bauer disk diffusion method while presence of ESBLs was checked by double disk synergy test and PCR. The results of present study showed that among 100 meat samples, potentially pathogenic *E. coli* was isolated from 36 samples with greater contamination 20/50 (40%) in chicken samples in comparison to mutton 16/50 (32%). Similarly, the frequency of *E. coli* was more pronounced in fresh meat 30/50 (60%) rather than frozen 4/50 (8%). The highest resistance pattern (100%) was observed against ampicillin, ciprofloxacin, vancomycin and tetracycline followed by cefotaxime (91.6%) and (n=27) isolates were found multi drug resistant (MDR). The double disk synergy test found 17 (47.22%) ESBL producing isolates while *bla* CTX-M gene was identified in 5 (29.41%) isolates followed by *bla* OXA-48 in 4 (23.52%) samples and *bla* TEM gene in 1 (5.88%). This study revealed that vigilant control procedures should be implemented all over the food chain and effective surveillance should also be performed at national level to minimize the spread of MDR and ESBL producing *Escherichia coli* from raw meat.

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**INTRODUCTION**

*Escherichia coli* is considered top ranked foodborne pathogen within *Enterobacteriaceae* family. Most of *E. coli* strains are non-pathogenic but few are responsible for gastrointestinal issues including diarrhea in infants, children and adults, urinary tract infections and meningitis (Gallardo et al., 2017). Poultry is recognized as main source of *E. coli* dissemination among environment, human community and animals. The pathogenic strains of *E. coli* in poultry often results in difficult to treat infections posing a direct threat to poultry industry and human health. Extraintestinal pathogenic *E. coli* (ExPEC) causes severe losses in poultry in form of mortality and morbidity due to colibacillosis and also recognized as avian pathogenic *Escherichia coli* (APEC) (Bélanger et al., 2011). These ExPEC can also cause variety of human extraintestinal diseases like neonatal meningitis, urinary tract infections and sepsis (Ranjan et al., 2017). Despite of these ExPEC, poultry gut also accommodates various pathogenic intestinal *E. coli* (Lutful Kabir, 2010). *Enterohemorrhagic E. coli* (EHEC) is also a common intestinal reservoir of cattle, sheep, goat and chicken. EHEC is transmitted to human community primarily via consumption of contaminated raw milk, meat and undercooked meat products (Sethulekshm et al., 2016).
Meat and meat products are among the most important edible commodities of animal origin like cattle, sheep and poultry. Contaminated meat is a vital source of food borne illness due to the fact that it has favorable conditions and nutrients for the efficient growth of pathogenic microorganisms such as proteins, fermentable carbohydrates, minerals and growth factors (Datta et al., 2012). Pathogenic strains of Escherichia coli are cause of foodborne illness in humans when ingested. Contamination of meat during slaughtering process can occur as a result of direct or indirect contact with feces, contaminated tools, skin, equipments, personnel and their clothings (Adzitey, 2015). The irrational and excessive usage of antibiotics for the treatment of food animals is the reason behind development of multidrug resistance in microorganisms creating a serious public health threat. This resistance is shifted to humans by consumption of meat and its products (Mouiche et al., 2019).

There are various strategies which bacteria can adopt to attain drug resistance including enzymatic degradation of drugs, active efflux and alteration in the target site of drugs. The degradation by beta lactamase enzymes is the key mechanism for acquired resistance against beta lactam antibiotics. The increasing trend and spread of extended spectrum beta lactamase (ESBL) producing bacteria are posing a serious threat because they can degenerate clinically important 3rd as well as 4th generation cephalosporins but unable to inactivate carbapenems (Rahman et al., 2018).

The ESBLs are mostly produced among Enterobacteriaceae, predominantly in Escherichia coli. Moreover, E. coli encoding ESBLs are resistant to more than two classes of antimicrobials and referred as multidrug resistant (MDR), presenting a serious challenge in healthcare settings as very few treatment options are left for treatment (Meletis, 2016). Many studies on ESBL producing E. coli from clinical settings have been conducted in Pakistan during past few years but there are very few reports regarding their prevalence in meat samples from Pakistan. Due to these facts, the current research was planned to find out incidence of ESBL producing E. coli in fresh and frozen meat samples from Pakistan.

**MATERIALS AND METHODS**

**Samples collection:** Total (n=100) fresh and frozen meat samples (poultry and mutton) were collected from various butcher shops and super markets. Fifty samples were collected from each category and equal numbers of samples were collected from chicken and mutton. The samples were carefully packaged into polyethylene bags, labeled properly then transferred in the icebox to the laboratory for further processing.

**Isolation and identification of Escherichia coli:** A 25 g of each meat specimen was mixed aseptically in the 225 ml of sterilize peptone water and subjected to overnight enrichment followed by inoculation on MacConkey’s agar or Eosin Methylene Blue (EMB) agar (Oxoid, UK) and incubated for 24-48 hours at 37°C aerobically Pinkish colonies on MacConkey agar or distinct metallic green colonies on EMB agar indicated positive growth for E. coli which was further confirmed by Gram’s staining and biochemical tests (Nawaz et al., 2019). Preservation of isolates was done in brain heart infusion with 30% glycerol and stored at -80°C (Rahman et al., 2018).

**Molecular confirmation of Escherichia coli:** Molecular confirmation of isolates was done by polymerase chain reaction (PCR) targeting the uidA (b-glucuronidase) gene. The DNA was separated using commercial Kit (Thermo Scientific, USA), PCR was performed in thermal cycler (Bio Rad, USA) and products were visualized using 1% gel by electrophoresis as described by (Maynou et al., 2017).

**Antimicrobial susceptibility testing:** After the confirmation of E. coli, antibiotic susceptibility profile of all isolates was investigated against commonly used antimicrobials including ampicillin, amoxicillin/ clavulanic acid, Amikacin, Cefotaxime, Ciprofloxacain, Ceftriaxone, Ceftazidime, Gantamicin, Tetracycline, Vancomycine, Imipenen, Meropenem and Dorepenem. The result analysis was done according to the guidelines of Clinical Laboratory Standards Institute as described by (Nawaz et al., 2019).

**Phenotypic detection of ESBL production:** Modified double disc synergy test (MDDST) was used for detection of ESBL producing E. coli using cefotaxime (CTX, 30 μg), ceftazidime (CAZ, 30 μg), ceftriaxone (CRO, 30 μg) and amoxicillin-clavulanate (20/10 μg) discs. The strains ATCC 35218 and ATCC 25922 were used as negative and positive controls of E. coli, respectively. Amoxicillin-clavulanate (20/10 μg) disc was placed to center of the agar plate and other antibiotics discs were placed at 15 to 20mm distance. The ESBL production considered as positive as any increase in zone in the direction of disc of amoxicillin-clavulanate (Saleem et al., 2017).

**Identification of ESBL encoding genes:** The isolates of Escherichia coli showing positive phenotypic ESBL detection were processed for the identification of extended spectrum beta lactamase encoding genes using specific primers by PCR (Table 1). The targeted ESBL genes were bla CTX-M, bla TEM and bla OXA-48 (Hosseinzadeh et al., 2018; Nawaz et al., 2019).

**Statistical analysis:** The variables were presented in form of percentages (%). The value (P<0.05) was considered as significant. All the statistical analyses were performed by Stata 11 software (Stata Corp, USA).

**RESULTS**

The results of present study showed that out of 100 meat samples, (n=36) were identified as Escherichia coli on the basis of standard microbiological and molecular methods (Fig. 1). The prevalence of E. coli was recorded higher 20/50 (40%) in chicken meat as compared to 16/50 (32%) in mutton. Moreover, the detection of E. coli was found significantly more pronounced in fresh meat samples 30/50 (60%) rather than frozen meat 4/50 (8%). Greater trend of E. coli was found in fresh chicken meat 44.40% than frozen chicken 11.10% (P=0.021). Similarly, significant variation was found between the fresh mutton and frozen mutton (P=0.007) as described in Table 2.
Table 1: Name and sequences of primers used for PCR amplification

| Primers Name | Sequence | Product size | References |
|--------------|----------|--------------|------------|
| uidA-F       | ATCACCGTGTGACGCGATGTCGC | 486bp | (Maynou et al., 2017) |
| uidA-R       | CACACCGATGCCCATGTCTCGGC | 438bp | (Hosseinzadeh et al., 2018) |
| bla OXA-1 *F* | GCGTGTTAGAGCGAAGAC | 862bp | (Egale et al., 2017) |
| bla OXA-1 *R* | CATCAAGTCCACCAACCC | 780bp | (Bello-López et al., 2017) |
| bla TEM F     | ATGAGTATTCAACATTTCCG |              |            |
| bla TEM R     | GACAGTCTTCAAGTCATTCATCA |              |            |
| bla CTX-M F   | CGTACCGCTGTGTGTAAGGA |              |            |
| bla CTX-M R   | ACGGCTTTCTGCCTTAGGTT |              |            |

Antimicrobial susceptibility profile of Escherichia coli: Different isolates of E. coli showed variable pattern of antibiotic susceptibility against various antimicrobial agents. The resistance to not less than 3 different class of antibiotics was observed in (n=27) 75% of the E. coli isolates and these isolates were therefore referred as MDR. All the E. coli isolates (100%) were found resistant to ampicillin, ciprofloxacin, vancomycin and tetracycline while 91.6% showed resistance against cefotaxime. Furthermore, 66.66% isolates were detected resistant to three drugs, ceftazidime, gentamicin and amoxicillin /clavulanic acid. The highest sensitivity was observed to imipenem (66.66%) as shown in Table 3.

Frequency of ESBL producing Escherichia coli: The double disk synergy test showed that phenotypically 17 out of 36 (47.22%) isolates of E. coli were ESBL producers. Among these ESBL positive (n=17) isolates, bla CTX-M gene was identified from 5 (29.41%) isolates followed by bla OXA-48 from 4 (23.52%) and bla TEM gene was detected from 1 (5.88%) isolate.

**DISCUSSION**

Over the last decade, ESBL producing E. coli has been frequently contaminating the meat of food animals and posing a global threat to public health and food security. Mostly these isolates are MDR in nature, which increase the challenge for their treatment and eradication. The multi drug resistance is getting more serious in Pakistan where antibiotic usage is not strictly regulated (Rahman et al., 2018).

The present study was designed to isolate and identify E. coli from fresh and frozen meat samples followed by estimation of their antimicrobial susceptibility and presence of ESBL genes. In this study, the prevalence of E. coli was found 36% (36/100) and similar findings with 35.40 % prevalence were reported in Nepal (Saud et al., 2019) and 20.40% in chicken meat in Iran (Safarpordehkordi et al., 2014). Conversely, a much higher prevalence (75%) of E. coli was reported in 2015 (El-Tawab et al., 2015) and 49% in raw chicken meat in Bangladesh (Rahman et al., 2017). The variation in the results recorded by different scientist was due to contamination of collection sites and type of meat samples. It was found that E. coli was more prevalent in fresh chicken and mutton meat samples then in frozen meat. The poor hygienic handling and processing is mainly responsible for the E. coli contamination in meat. Same type of findings was also recorded in Saudi Arab (Hemeg, 2018) as the growth of Escherichia coli cells is impaired at temperatures below 21°C and stops at 7.5°C.
The antimicrobial susceptibility profiling was done for (n=36) *E. coli* isolates against 14 different antibiotics. The results showed highest resistance pattern (100%) against ampicillin, ciprofloxacin, vancomycin and tetracycline followed by ceftaxime (91.6%). The results finding of Adzitey (2015) and Dehkordi et al. (2014) showed higher resistance to ciprofloxacin and ampicillin, while the results of Nahar et al. (2018) showed 100% resistance to ampicillin and ceftaxime. *E. coli* isolates 75% (n=27) were categorized as multi drug resistant *Escherichia coli* (MDR-EC). The increased trend of multi drug resistant *E. coli* was also reported by Ahmed et al. (2009) in Japan, Adzitey (2015) in Ghana, Altalhi et al. (2010) in Saudi Arabia, Dehkordi et al. (2014) in Iran and Abdel-Rahman et al. (2015) in Egypt. This difference in results of antibiotic susceptibility profile was due to excessive use of antibiotics in commercial poultry and veterinary practice for both prevention and treatment. Among the carbapenems, highest resistance was found against doripenem (38.89%) and meropenem (25%) which is comparable to the findings of Batool et al. (2016) in Pakistan and Ahmed et al. (2009) in Japan while these results are in contrast with the findings of Zhao et al. (2018).

The results of present study showed 47.22% (n=17) isolates were ESBL producers phenotypically using double disk synergy test which is very close to the findings of Hussain et al. (2017) with 46% from India and Rahman et al. (2018) with 47.6% in Pakistan. A much-elevated level (70%) of ESBL producing *E. coli* was detected by Saleem et al. (2017) in Pakistan and Nahar et al. (2018) from Japan. This elevated level of ESBL producing *E. coli* in the meat of food animals is posing a potential threat to humans. It was also observed that among the phenotypically ESBL positive (n=17) *E. coli* isolates; blaCTX-M gene was detected in 5 (29.41%) isolates which is also supported by Chishimba et al. (2016) in Zambia with 13% presence of blaCTX-M, 58% in South Africa by Montso et al. (2019) and 75% in Ghana by Eibach et al. (2018). Furthermore, bla OXA-as was detected in 4 (23.52%) and bla TEM gene was found in only 1 (5.88%) isolate. The results of Falgenhauer et al. (2019) also supported the fact that blaCTX-M is the most prominent type of ESBL present in meat samples followed by bla TEM.

Conclusions: The results of current study concluded that poultry and mutton meat samples were contaminated with MDR- *Escherichia coli* and this contamination was more pronounced in fresh meat samples. Chicken meat is highly contaminated with *E. coli* than mutton and increased occurrence of ESBL-EC in meat robustly suggest for involvement of efforts to drop this emerging challenge of drug resistance.

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Authors contribution: ZN and ABS conceived and designed the study; MM and MUQ performed the experiments; BA and RA compiled the data and results; MAZ, SA and AR wrote and critically reviewed the manuscript.

REFERENCES

Abdel-Rahman SH, Khalifa SM, El Galli KHA, et al. 2015. Prevalence of toxins and antimicrobial resistance among *E. coli* isolated from meat. Adv Microbiol 5:737-8.

Adzitey F. 2015. Antibiotic resistance of *Escherichia coli* isolated from beef and its related samples in Techiman municipality of Ghana. Asian J Animal Sci 9:233-40.

Ahmed AM, Shimabukuro H and Shimamoto T. 2009. Isolation and molecular characterization of multidrug-resistant strains of *Escherichia coli* and *Salmonella* from Retail Chicken Meat in Japan. J Food Sci 74:405-10.

Altalhi AD, Gherawy YA and Hassan SA. 2010. Antibiotic resistance in *Escherichia coli* isolated from retail raw chicken meat in Taif, Saudi Arabia. Foodborne Pathog Dis 7:281-5.

Batool A, Baig H and Qamar MU. 2016. Extended spectrum-lactamase producing *Escherichia coli* and *Klebsiella pneumoniae* causing urinary tract infection. Afr J Microbiol Res 10:1775-8.

Bélangé L, Garenaux A, Harel J, et al. 2011. *Escherichia coli* from animal reservoirs as a potential source of human extraintestinal pathogenic *E. coli*. FEMS Immunol Med Microbiol 62:1-10.

Bello-López JM and Rojo-Medina J. 2017. Detection of antibiotic resistance genes β-lactams in bacterial strains isolated from Umbilical Cord Blood Units for transplant. Rev Méd Hosp Gen México 80:31-6.

Chishimba K, Hang’Ombe BM, Muwando Z, et al. 2016. Detection of extended-spectrum beta-lactamase-producing *Escherichia coli* in market-ready chickens in Zambia. Int J Microbiol 16:1-5.

Datta S, Akter A, Shah IG, et al., 2012. Microbiological quality assessment of raw meat and meat products and antibiotic susceptibility of isolated *Staphylococcus aureus*. Agric Food Anal Microbiol 2:187-94.

Dehkordi FS, Yazdani F and Mozafari J. 2014. Virulence factors, serogroups and antimicrobial resistance properties of *Escherichia coli* strains in fermented dairy products. BMC Res Notes 7:217.

Egule T, Birungi J, Asrat D, et al., 2017. Genetic markers associated with resistance to beta-lactam and quinolone antimicrobials in *non*-*typhoidal Salmonella* isolates from humans and animals in central Ethiopia. Antimicrob Resist Infect Control 6:13.

Eibach D, Dekker D, Boahen K, et al., 2018. Extended-spectrum beta-lactamase-producing *Escherichia coli* and *Klebsiella pneumoniae* in local and imported poultry meat in Ghana. Vet Microbiol 217:7-12.

El Tawab AAA, El-Holy FI, Nada SM, et al., 2015. Detection of virulence genes of *enterohemorrhagic* *E. coli* isolated from some meat products by polymerase chain reaction. Benha Vet Med J 29:45-52.

Falgenhauer J, Imirzalioglu C, Falgenhauer L, et al., 2019. Whole-Genome Sequences of clinical *Enterobacter bugandensis* isolates from Germany. Microbiol Resour Announc 8:e00463.

Gallardo F, Izquierdo M, Vidal RM, et al., 2017. Distinctive gut microbiota is associated with diarrheagenic *Escherichia coli* infections in children. Front Cell Infect Microbiol 7:424.

Hemeg HA. 2018. Molecular characterization of antibiotic resistant *Escherichia coli* isolates recovered from food samples and outpatient Clinics, KSA. Saudi J Biol Sci 25:928-31.

Hosseinzadeh Z, Saraje HSE, Sarvari J, et al., 2018. Emerge of *bla* _NDM-1_ and *bla* _OXA-48_-like harboring carbapenem-resistant *Klebsiella pneumoniae* isolates from hospitalized patients in southwestern Iran. J Chin Med Assoc 81:536-40.

Hussain A, Shaik S, Ranjan A, et al., 2017. Risk of transmission of antimicrobial resistant *Escherichia coli* from commercial broiler and free-range retail chicken in India. Front Microbiol 8:2120.

Lutful Kabir SM, 2010. Avian colibacillosis and salmonellosis: a closer look at epidemiology, pathogenesis, diagnosis, control and public health concerns. Int J Environ Res Public Health 7:899-114.

Maynou G, Bach A and Terré M, 2017. Feeding of waste milk to Holstein calves affects antimicrobial resistance of *Escherichia coli* and *Pasteurella multocida* isolated from fecal and nasal swabs. J Dairy Sci 100:2680-94.

Meletis G. 2016. Carbapenem resistance: overview of the problem and future perspectives. Therap Adv Infect Dis 3:15-21.

Montso KP, Dlamini SB, Kumar A, et al., 2019. Antimicrobial resistance factors of Extended-Spectrum Beta-Lactamases producing
Escherichia coli and Klebsiella pneumoniae isolated from cattle farms and raw beef in North-West province, South Africa. BioMed Res Int 2019:4318306.

Mouiche MMM, Moffo F, Akpochere JTK, et al., 2019. Antimicrobial resistance from a one health perspective in Cameroon: A systematic review and meta-analysis. BMC Public Health 19:1135.

Nahar A, Awasthi SP, Hatanaka N, et al., 2018. Prevalence and characteristics of extended-spectrum β-lactamase-producing Escherichia coli in domestic and imported chicken meats in Japan. J Vet Med Sci 80:510-7.

Nawaz Z, Zahoor MK, Siddique AB, et al., 2019. Molecular identification of blaCTX-M and blaTEM genes among multidrug resistant Enteropathogenic Escherichia coli isolated from children. Pak J Pharm Sci 32:1215-8.

Rahman MA, Rahman AKMA, Islam MA, et al., 2017. Antimicrobial resistance of Escherichia coli isolated from milk, beef and chicken meat in Bangladesh. Bangl J Vet Med 15:141-6.

Rahman SU, Ali T, Ali I, et al., 2018. The growing genetic and functional diversity of extended spectrum Beta-Lactamases. BioMed Res Int pp.9519718.

Rahman SU, Ahmad S and Khan I, 2018. Incidence of ESBL-producing Escherichia coli in poultry farm environment and retail poultry meat. Pak Vet J 39:116-20.

Ranjana, Shaik S, Nandanwar N, et al., 2017. Comparative genomics of Escherichia coli isolated from skin and soft tissue and other extraintestinal infections. MBio 8:e01070-17.

Safarpordehkordi F, Yahaghi E and Khodaverdi DE, 2014. Prevalence of antibiotic resistance in Escherichia coli isolated from poultry meat supply in Isfahan. Iran J Med Microbiol 8: 41-7.

Saleem R, Ejaz H, Zafar A, et al., 2017. Phenotypic characterization of extended-spectrum-beta-lactamase producing E. coli from healthy individuals, patients, sewage sludge, cattle, chickens and raw meat. Pak J Med Sci 33:886-90.

Saud B, Paudel G, Khichaju S, et al., 2019. Multidrug-Resistant bacteria from raw meat of buffalo and chicken, Nepal. Vet Med Int 2019:1-7.

Sethulekshmi C, Latha C and Sunil B, 2016. Occurrence of Enterohaemorrhagic E. coli in raw meat samples in Kerala. Int J Adv Res Bio Sci 3:220-2.

Zhao M, Huang D, Zhang X, et al., 2018. Metabolic engineering of Escherichia coli for producing adipic acid through the reverse adipate-degradation pathway. Metab Eng 47:254-62.