



## EXTENDED-SPECTRUM $\beta$ -LACTAMASE (ESBL) - PRODUCING *ESCHERICHIA COLI* FROM POULTRY – A REVIEW

### Veterinary Science

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### ABSTRACT

During the last few decades, Extended-spectrum  $\beta$ -lactamase (ESBL) - producing *Escherichia coli* has been isolated in humans as well as in livestock, including chickens, and the prevalence has been increased significantly for unidentified reasons. *E. coli* acts as a major opportunistic pathogen in chickens and has a potential for zoonotic transfer to human beings, ESBL-producing *E. coli* represents a major risk to poultry production as well as to human health. Here we reviewed the data on some of the existing problems with ESBL-producing *E. coli* in relation to poultry production, with a focus on chickens. This review highlights the occurrence of antimicrobial resistance in *E. coli* of poultry origin in relation to Extended-spectrum  $\beta$ -lactamase (ESBL) - producing *Escherichia coli*.

### KEYWORDS

*E. coli*, Antimicrobial resistance, ESBL, poultry

Even before the first  $\beta$ -lactam antibiotic, penicillin was developed, resistance to  $\beta$ -lactam antibiotics was detected. The first  $\beta$ -lactamase was detected in *Escherichia coli* prior to the use of penicillin in medical practice (Abraham and Chain, 1940). Many gram-negative bacteria possess a naturally occurring, chromosomally mediated  $\beta$ -lactamase.

Over the last 20 years, many new  $\beta$ -lactamases have emerged due to selective pressure of the use and overuse of new  $\beta$ -lactam antibiotics in the treatment of patients. Presumably, one of the important class was the extended spectrum  $\beta$ -lactamases (ESBLs) which confers resistance to oxyimino-cephalosporins, which became widely used for the treatment of serious infections caused by gram-negative bacteria in the 1980s. Today, there are more than 150 different ESBLs have been detected and found worldwide in many different genera of *Enterobacteriaceae* and *P. aeruginosa*.

The three  $\beta$ -lactamases TEM, SHV and CTX-M are the most important representatives of ESBLs in relation to *E. coli* colonizing and infecting poultry. TEM-1 (named after the patient Temoneira) was the first plasmid-mediated  $\beta$ -lactamase described in the early 1960s (Datta and Kontomichalou, 1965). SHV-1 (sulphydryl variable) is another commonly found plasmid mediated  $\beta$ -lactamase in *Klebsiella pneumoniae* and *E. coli*. The SHV-1  $\beta$ -lactamase is usually plasmid mediated in *E. coli*. The third important  $\beta$ -lactamase, CTX-M (active against cephotaxime) was first isolated from Munich, Germany. Since, third generation cephalosporin group of antibiotics are used to treat most dangerous human infections, resistance against this group of antibiotics is most dangerous.

Extended spectrum Beta-lactamase (ESBL) *E. coli* are frequently present in the gastrointestinal tract of animals (Carattoli, 2008; Coque *et al.*, 2008) and have been isolated from swine, cattle, poultry (Hiroi *et al.*, 2011). The gastrointestinal tract of animals is considered as an important reservoir for bacteria producing ESBLs, and a potential source for human pathogens to take up these resistance genes (Akinlabi *et al.*, 2008; Borjesson *et al.*, 2013). *E. coli* is a major opportunistic pathogen in chickens and although it is uncertain whether ESBL *E. coli* represents a direct threat to poultry production, ESBL *E. coli* certainly represents a major problem to human clinical medicine. However, controversies exist about the zoonotic potential of ESBL *E. coli*. (Olsen *et al.*, 2014)

In the present review, we sum up the phenotypic pattern of ESBL producing *E. coli* isolated from poultry from India as well as around the world. This review highlights the importance of monitoring and surveillance of ESBL-producing *E. coli* from poultry and thus justifies the urgent need of regulation of veterinary and human drug use to reduce the emergence of new ESBL-*E. coli*.

Worldwide many scientists have studied the pattern of ESBL-*E. coli* isolated from poultry. Hiroi *et al.* (2012) collected rectal samples from

broilers (30), and layers (17) to evaluate the diversity of extended-spectrum beta-lactamases (ESBL) genes among food-producing animals. Phenotypic disc diffusion test for ESBL production was done for all the isolates. A total of 42 ESBL-producing *E. coli* strains were detected. 41 and 1 ESBL producing *E. coli* strains were derived from 30 broilers and 17 layers, respectively. Similarly, Kamayema *et al.* (2013) examined 41 rectal samples taken from 4 commercial farms in Japan to study the prevalence of extended-spectrum cephalosporin (ESC)-resistant *Enterobacteriaceae* in broiler chickens. One hundred and sixty three ESC-resistant *E. coli* isolates were enumerated. The phenotypic confirmatory test of ESBLs showed that 34 (77.3%), 12 (30%), 14 (35%) and 13 (37.5%) of the ESC-resistant isolates originating from Farms 1, 2, 3 and 4, respectively, were putative ESBL producers (73 isolates in total, 44.5%).

Boonyasiri *et al.* (2014) investigated the prevalence of extended-spectrum beta-lactamase (ESBL) producing *E. coli*, in samples collected from rectal swabs of healthy chickens (n-305). Extended-spectrum beta-lactamase production was assayed using a double disk diffusion method. 40% of the *E. coli* isolated from rectal swabs were found to be ESBL producers. Blaak *et al.* (2015) designed a study which aimed to discern the contribution of poultry farms to the contamination of the environment with ESBL-producing *E. coli* and therewith, potentially to the spread of these bacteria to humans and other animals. Overall, 471 samples were taken, 276 from broiler farms and 195 from laying hen farms. ESBL-producing *E. coli* were present in 65% and 81% of poultry feces samples at laying hen and broiler farms, respectively. Dahms *et al.* (2015) tested rectal swabs from 6 poultry farms to investigate the prevalence of ESBL-producing *Escherichia* spp. in poultry farms. Phenotypic testing for ESBL production revealed that three of six poultry (50%) farms turned out to be positive for ESBL-producing *E. coli*, all of which were broiler farms. Li *et al.* (2016) investigated the prevalence and drug resistance characteristics of ESBL-producing *E. coli* in healthy broilers from Shandong Province. A total of 142 (88.8%) ESBL-producing *E. coli* isolates were detected out of 160 from four prefectures in Shandong Province from October 2014 to February 2015.

Some workers have detected ESBL-producing *E. coli* from frozen as well as freshly slaughtered chicken. Kola *et al.* (2012) tested 399 chicken samples to determine the prevalence of ESBL producing *Enterobacteriaceae* in chicken meat in Germany. Phenotypic confirmatory test was used to detect putative ESBL producers. Out of 81 putative ESBL-producing *Enterobacteriaceae* isolates from 80 samples from Berlin market, 93.83% (n-76) were *E. coli* while 155 putative ESBL-producing bacteria from 123 samples from nine stores in Greifswald, 87.10% (n-135) were *E. coli*. Schaumburg *et al.* (2014) analyzed 151 frozen chicken meat samples (88 legs, 63 wings) imported from industrialized countries to Gabon for ESBL producing *E. coli*. The prevalence of ESBL *E. coli* in chicken meat was 23% (n = 14 of 60). Zarfel *et al.* (2014) analyzed 50 chicken samples from Austria for the presence of ESBL *Enterobacteriaceae*. 26 different

ESBL *E. coli* were detected from 21 samples; no other ESBL positive *Enterobacteriaceae* species were recovered. Rasmussen *et al.* (2015) tested *E. coli* isolates from locally chicken samples and imported meat (109) as well as from the cloaca of locally reared chicken (44). Phenotypic confirmatory test for ESBL revealed that 4 isolates from local meat and 15 from imported meat were ESBL-producers while only 1 isolate from cloaca was positive for ESBL test. One isolate from local meat was positive for both ESBL and AmpC production. Koga *et al.* (2015b) screened a total of 84 *E. coli* strains isolated from chicken carcasses in 2007 and 121 *E. coli* strains isolated in 2013 for ESBL production by double-disk diffusion testing for amoxicillin/clavulanate and cefotaxime or ceftazidime, or by using a combination disk test with cefotaxime, cefotaxime+ clavulanic acid, ceftazidime and ceftazidime + clavulanic acid. Thirty-nine strains present in 17 chicken carcasses (65.4% of carcasses analyzed in 2013) were positive in the ESBL test in 2013.

Le *et al.* (2015) compared the prevalence of ESBL-producing *E. coli* in a total of 253 food samples from poultry, pork, shrimp, and fish were collected from local markets in a rural area of Vietnam from 2013 to 2014. A high percentage (68.4 %) of the tested poultry, pork, shrimp, and fish samples was contaminated with ESBL-*E. coli*. The prevalence of ESBL-producing *E. coli* in the tested samples varied significantly from 50.7 % in pork to 88.3 % in poultry. Maximum prevalence of ESBL producing *E. coli* was found in poultry.

ESBL pattern among poultry origin Indian *E. coli* isolates was studied by few authors in India. Lalzampuia *et al.* (2014) conducted a study to record the association of extended spectrum  $\beta$ -lactamases (ESBLs) producing enteric bacteria with diarrhea of poultry birds in Mizoram, India. A total of 134 enteric bacteria were isolated from fecal samples of poultry with the history of diarrhea out of which 102 (76.12%) were *E. coli*. All the isolates were subjected to antibiotic sensitivity assays by double discs synergy test (DDST) method. By DDST 6 isolates were ESBL producer. Kar *et al.* (2016) designed a study to determine the occurrence of extended spectrum beta-lactamase (ESBL) producing *E. coli* isolated from poultry in Odisha, India. Of 170 fecal samples screened from poultry, total 18 *E. coli* isolates, from 16 different poultry fecal samples were putatively identified as ESBL producers by phenotypic screening test i.e. combination disc method. From this review, it is further recommended that more extensive surveillance and monitoring on the phenotypic resistance pattern of *E. coli* from poultry origin should be undertaken and the genotypic characterization of the same is suggested. These type of studies will help in tracing out the origin of antimicrobial resistant bacteria from poultry origin.

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