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OCCURRENCE AND ANTIMICROBIAL RESISTANCE OF *SALMONELLAE* ISOLATED FROM BROILER'S LIVER AND WASHING WATER OBTAINED FROM SMALL-SCALE POULTRY PROCESSING PLANTS

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ABSTRACT

In this investigation, fifty-five chicken livers and washing water samples were gathered from the small-scale poultry processing plants in Cairo and Giza governorate, Egypt. *Salmonella* occurrence was detected, identified, and finally phenotypically characterized for the most common antibiotic groups to detect its antibiotic resistance profiles. *Salmonella* species have been recovered from 1 out of 45 (2.2%) examined chicken livers. This isolate was biochemically identified and molecularly verified such as *Salmonella* by the *invA* gene detection using PCR. The *Salmonella* serovar was recognized as *S.* Anatum. The isolated *S.* Anatum showed resistance to ten antimicrobial agents among six antimicrobial classes, so this isolate was classified as MDR. Its resistance was against gentamicin, ampicillin, ciprofloxacin, tetracycline, chloramphenicol, cefepime, ceftazidime, ceftriaxone, cefotaxime, and aztreonam. In conclusion, chicken livers were contaminated with MDR *Salmonella* serovars, which could be extremely dangerous for human health. To control such food poisoning hazards, the necessity to implement food safety systems is imperative. Additionally, continuous updating of the occurrence and antibiotic resistance profile regarding *Salmonella* is an important food safety issue.

Keywords: *S.* Anatum; *invA* gene; chicken livers; washing water; MDR; Cefotaxime.

INTRODUCTION

Salmonella infections in chicken flocks can result in acute and chronic clinical disorders, but in recent years, their connection to human sickness outbreaks through contaminated food has garnered more attention on a global scale (Gast *et al.*, 2020). Non-typhoidal type of *Salmonella* is the first and most popular food-borne infection and a serious hazard to public health, resulting in 78.7 million illness cases and 59,000 fatalities each year (Majowicz *et al*., 2010**)**. *S.* Enteritidis and *S.* Typhimurium are among the majority of frequent serotypes identified from chicken carcasses retailers globally, even though *Salmonella* serotypes differ widely (Li *et al.*, 2020, Abd-Elghany *et al.*, 2015). Additionally, 60–90% of human salmonellosis globally is associated with *S.*

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Typhimurium, followed by *S.* Enteritidis (Thung *et al.*, 2018). As a result, their increased incidence among *Salmonella* isolates found in chicken carcasses purchased at the grocery store level is taken into consideration as a potential food safety concern. Amongst the extremely common food-borne infections in the Middle East and North Africa is salmonellosis, which places a heavy financial burden on global healthcare systems (Faour-Klingbeil *et al.*, 2020). In the USA, the cost of foodborne salmonellosis linked to chicken eating typically ranges from 1.1 to 2.8 billion dollars annually (Scharff, 2020). Salmonellosis is a contagious food poisoning infection that creates a significant socioeconomic impact on the public healthcare systems in Egypt. Despite this, Egypt lacks a global surveillance program that would provide accurate statistics on the prevalence of the disease.

The numerous virulence genes found in *Salmonella* serovars, which are grouped under five *Salmonella* pathogenicity islands, have the potential to cause serious illnesses (SPI-1 to SPI-5). The type-III secretory system (T3SS), which is composed of the proteins expressed by the SPI-1 and SPI-2 genes, is included in the penetration and adhesion of *Salmonella* to cells in the body (Hussain *et al.*, 2021). A special marker called *Salmonella* invasion A (*invA*) facilitates the inclusion of pathogen cells into the target intestinal epithelium of patients (Lan *et al.*, 2018). The *Salmonella stn* gene codes for an enterotoxin called *stn* and is linked to infection with *Salmonella* serotypes Typhi, Typhimurium, and Enteritidis which cause severe symptoms such as diarrhea (Prager *et al.*, 1995).

Chicken meat is characterized by low fat and cholesterol level and lacks any cultural or religious limitations; chicken is a well-known, affordable and healthy source of animal protein. In Egypt consumers, regardless of their level of income, prefer poultry meat, especially chicken meat. Approximately, 1.2 billion chickens or 1125 million tons of chicken flesh are consumed per year (Shatokhin *et al.*, 2017). Chicken carcasses are contaminated mostly throughout different processing phases, including the slaughter of animals, evisceration, scalding, washing, plucking, chilling, and storage at retail stores since in several small-scale processing plants, chicken flesh has been connected to numerous human salmonellosis infections (Tarabees *et al.*, 2017).

The procedure of gutting causes the carcasses to contain significant quantities of bacteria from feathers of birds, paws, and feces in addition to cross-contamination from the preparation area and workers (Thomas *et al.*, 1980). Then, they are washed internally and externally using pressurized water to achieve three goals: get rid of any blood, debris, and feather residue from the skin; minimize surface contamination, and prevent further drying in the refrigeration systems. Washing is a crucial step since it gets rid of a lot of bacteria from processed carcasses, so the slaughterhouse's "clean zone" officially starts at the washing step. Moreover, operations are done in this area at carefully regulated low temperatures to prevent contamination. Therefore, water is among the most essential resources used in poultry processing plants because it is used in washing and rinsing chickens (Cogan *et al.*, 2002). In poultry slaughterhouses, the water used for washing and rinsing the chickens must have antibacterial, such as chlorine and organic acids, moreover, renovation of the used water is necessary (Keener *et al.*, 2004). Concerning the small-scale processing facilities, all the previous conditions are not applied, and therefore the washing water will be a source of contamination for the chicken carcasses. Consequently, washing water in different small-scale processing plants is the main reason for the cross-contamination of different types of bacteria mainly the

Enterobacteriaceae group such as *Salmonella* and *Escherichia coli*.

Chickens raised for commercial purposes use a lot of feed. Numerous vital digestive, metabolic, and excretory processes that the liver performs have a key influence on the health and productivity of chickens (Procura *et al.,* 2019). Chicken liver is a food item that can be utilized in a variety of dishes, including rice, soups, and sauces due to it are high zinc, iron, and vitamin content. Giblets mostly the liver may include germs, such as *Salmonella*, which creates a major danger to the world's global health, causes major morbidity, and has a sizable financial impact (Abd El-Aziz, 2013).

Because of the extensive overuse and abuse of antimicrobials in chicken and animal rearing, multidrug-resistant (MDR) *Salmonella enterica* serotypes are increasingly becoming found in food derived from animals, posing a significant risk to both animal and people's health and potentially reducing the number of effective therapeutic choices available for the prevention and treatment of various human salmonellosis (Elshebrawy *et al.,* 2022). *Salmonella* isolates resistant to fluoroquinolones and cephalosporins, which have been regarded as the two greatest clinically significant antimicrobials to deal with human *Salmonella* poisoning, have been a large number of scientists around the world have observed over the past decades, leading to a significant increase in deaths and morbidity cases (Qiao *et al.,* 2017).

Consequently, the goal of this research is to observe the occurrence and antimicrobial resistance of *Salmonellae* isolated from broiler's liver and washing water obtained from different small-scale poultry processing facilities.

MATERIALS AND METHODS

1. Sampling

A total of forty-five samples from the liver of broiler chicken and ten washing water samples were collected from several shops and small-scale poultry processing plants distributed in Cairo and Giza governorate, Egypt, from September 2021 to December 2021. Each collected sample was separately packaged in a plastic bag then identified and transferred in an icebox to the Lab of Food Hygiene and Control Department, Cairo University, Egypt. Samples were investigated immediately after arrival.

2. Salmonella isolation and identification

The International Organization for Standardization's approach (ISO 6579-1, 2017) was used to isolate and identify *Salmonella* as follows: Each sample was transferred from its packaging to 225 ml of buffered peptone water (Oxoid**,** CM0509) into a sterilized plastic bag. Subsequently, the bag was violently agitated and homogenized in a stomacher for one minute at ambient temperature. Afterward, a sterile flask was used to transfer the solution, where it was incubated at 37 °C for 18 hours. 100 ul of the pre-enriched media was inoculated into 10 ml of RV (Rappaport-Vassiliadis) broth (Oxoid CM0669). The mixture was then incubated at 42 ± 2 °C/24 ± 2 h. The enriched broth was then streaked onto the Xylose-Lysine Desoxycholate (XLD) agar (Oxoid, CM0469) surface and the XLD agar plates were incubated at 37°C for 24 h.

Red-colored colonies either with or without black cores that appeared on XLD agar plates as suspected colonies were recognized using biochemical assays, including the urease, indole, triple sugar iron, Voges-Proskauer, citrate utilization, lysine decarboxylase, and methyl-red tests. Using the primers described in (Table 1) that address the *Salmonella* invasion gene (*invA*), all *Salmonella* isolates that were biochemically anticipated were submitted to serotyping and molecular identification by using the polymerase chain reaction.

3. DNA extraction of bacteria

Salmonella genomic DNA was isolated using the boiling technique (Reischl *et al.*, 1994).

4. Salmonella serotyping

The Kauffmann-White system was applied for the serological characterization of *Salmonella* isolates Kauffman (1974) that had undergone molecular confirmation employing commercial O and H antisera that are monovalent and polyvalent, in a reference laboratory for veterinary quality control on poultry production, Animal Health Research Institute, Dokki, Giza.

5. Molecular confirmation of Salmonella isolate

Invasion A gene (*invA*) of *Salmonella* was molecularly detected using a conventional PCR assay. The *invA* gene was amplified by using PCR. The process was carried out with a thermal pattern as follows: Denaturation (94 °C for 30 s), annealing (64 °C for 30 s), and extension (72 °C for 45 s), followed by a final extension at 72 °C for 10 min, while a particular band was found after the electrophoresis procedure at 284 bp (Rahn *et al.*, 1992).

6. Antimicrobial sensitivity testing of the isolated Salmonella

According to the procedure mentioned by the Clinical Laboratory Standards Institute's protocol (CLSI, 2020), the antimicrobial resistance profiles of each serotyped verified *Salmonella* serovar were assessed using the Kirby-Bauer disc diffusion standard method on Mueller-Hinton agar (Oxoid, CM0337). The eighteen antimicrobials examined belonged to 9 antibiotics categorized: Penicillins (Ampicillin, AMP, 10µg), macrolides (Azithromycin, AZM, 15µg), Cephalosporins (Cefoxitin, FOX, 10µg; Cefpodoxime, CPD, 10µg; Cefotaxime, CTX, 30µg; Cefepime, CPM, 10µg; Ceftazidime, CAZ, 30µg; aztreonam, ATM, 30µg; Ceftriaxone, CRO, 30µg), Fluoroquinolones (Ciprofloxacin, CIP, 5µg; Nalidixic acid, NA, 30µg), Aminoglycosides (Amikacin, AK, 30µg; Gentamicin, CN, 10µg), Sulphonamides (Sulphamethoxazole-Trimethoprim, SXT, 25µg), Tetracycline (Tetracycline, TE, 10µg), phenicols (Chloramphenicol), and Carbapenems (Meropenem, MEM, 10µg; Ertapenem, ETP, 10µg). *Salmonella* isolates were divided into three categories depending on their antimicrobial resistance patterns: extensively drug-resistant (XDR), multidrug-resistant (MDR), and pan-drug-resistant (PDR). MDR *Salmonella* isolates exhibited resistance to at least one antibiotic agent in three or more antimicrobial classes. While they were susceptible to only one or two antimicrobial classes, they were classified as extensively drug-resistant (XDR) when they showed resistance to at least one agent in all but two or fewer antimicrobial categories, and pan-drug-resistant (PDR) when they showed resistance to all drugs in all antimicrobial classes tested (Magiorakos *et al.*, 2012).

RESULTS

1. Occurrence of Salmonella spp. in washing water and livers of broilers

Salmonella spp. in both livers and washing water was detected by traditional methods that included cultivation, biochemical tests, and genetic confirmation through using the *invA* gene, and utilizing multivalent antisera for flagellar (H) and somatic (O) antigens for serological recognition. The occurrence of *Salmonella* among examined chicken liver and washing water is illustrated in (Table 2). *Salmonella* was isolated from one chicken liver out of 45 examined livers (2.2%). The isolated strain was identified as *Salmonella* Anatum. *Salmonella* was not detected in any of the examined washing water samples (Figure 1).

2. Molecular verification of Salmonella isolates by identification of invA gene

By amplifying the 284 bp *Salmonella* gene fragment (*invA* gene) using PCR, one *Salmonella* isolate was molecularly identified as *Salmonella* (Figure 2).

3. Antimicrobial resistance profiles of Salmonella isolate

The antibiotic sensitivity patterns of one serotyped verified *Salmonella* serovar against a range of 18 antibiotics are reported in (Table 3). Commonly, a bacterium strain could be considered an MDR when it displays resistance to a minimum of one antimicrobial drug in three or even more antimicrobial classes.

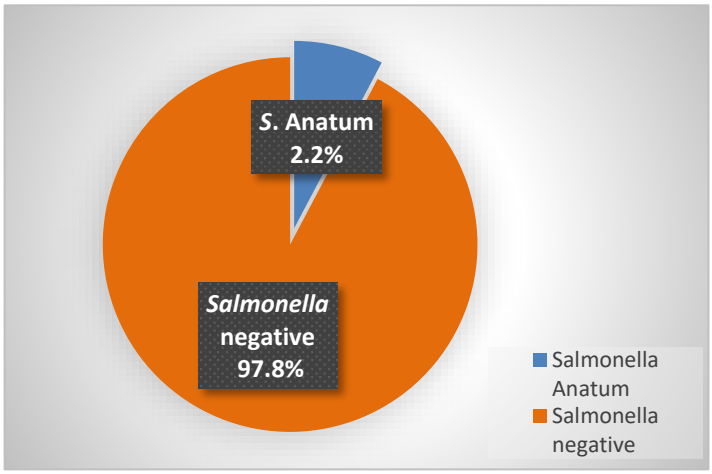

Figure 1. Occurrence of *Salmonella* serotype in chicken livers.

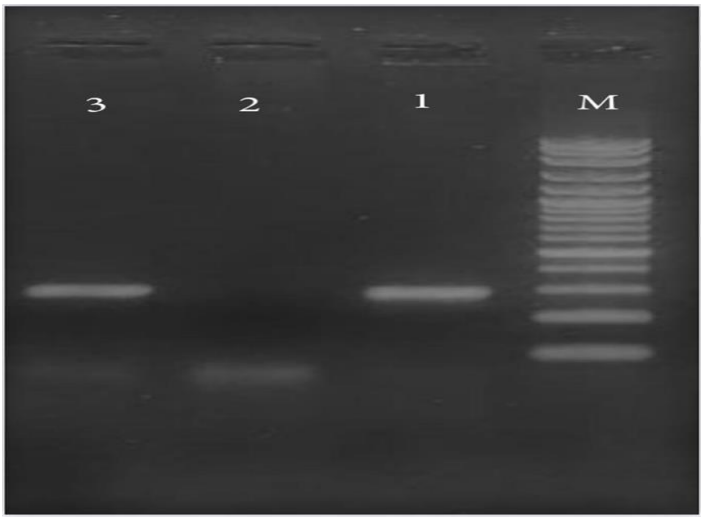

Figure 2. Occurrence of *invA* marker gene in recovered *Salmonella* Anatum from examined chicken livers.

Note: Lane M: DNA Ladder (100 bp); Lane 1: +ve control; Lane 2: -ve control; Lane 3: positive sample show specific band at 284 bp.

Table 1. Primer sequences were used for the identification of the *invA* marker gene

Target genes	Primer sequence (5'-3')	Length of PCR product	Company	References
InvA	F: GTGAAATTATCGCCACGTT CGGGCAA R: TCAT CGCACCGTCAAAGGAAGGAACC	284bp	Metabion, Germany	**(Rahn *et al.*, 1992).**

Table 2. Incidence of *Salmonella* in chicken liver and washing water

Sample type	No. of sample	+ve sample	percentage
Liver	45	1	2.2%
Washing water	10	_	_

Table 3. Antimicrobial resistance profiles of the *Salmonella* Anatum isolate (n=1) obtained from chicken livers

Antibiotic groups	Resistance profile
AK	S
CN	R
AMP	R
AZM	S
CIP	R
NA	S
SXT	S
TE	R
C	R
FOX	S
CPD	I
CTX	R
CAZ	R
CRO	R
CPM	R
ATM	R
MEM	S
ETP	S

AK=Amikacin;
CN=Gentamicin;
AMP=Ampicillin;
AZM=Azithromycin;
CIP=Ciprofloxacin;
NA=Nalidixic acid;
SXT=Sulfamethoxazole-trimetho Prim;
TE=Tetracycline;
C=Chloramphenicol;
FOX=Cefoxitin;
CPD=Cefpodoxime;
CTX=Cefotaxime;
CAZ=Ceftazidime;
CRO=Ceftriaxone;
CPM=Cefepime;
ATM=aztreonam;
MEM=Meropenem;
ETP=Ertapenem.
S=Susceptible.
R=Resistant.
I=Intermediate

DISCUSSION

The occurrence of *Salmonella* in poultry giblets and carcasses retailers varies by country and is influenced by many factors, including rates of *Salmonella* infection and contamination in slaughtered bird carcasses, methods of slaughter and preparation, potential cross-contamination at the store level, handling and storage conditions, sampling and collection techniques, and variations in *Salmonella* isolation methods between studies. Panzenhagen *et al.* (2016) summarized that the incidence rate of *Salmonella* in poultry carcasses was 88.2% (134/152) collected from retail shops in Cambodia. Moreover, *Salmonellae* could be isolated from 63.6% (302/475) of China's retail chicken flesh (Zhang *et al.,* 2018). However, a smaller percentage of *Salmonella* in chicken carcasses have been detected by several authors in many countries, For instance, Trinidad's rate was 8.3 % (Khan *et al.,* 2018), 18% was in purchased frozen and chilled chicken carcasses in Libya, In Iraq 11.5 % (Harb *et al.,* 2018), 23.7% in India, and 33.5 percent in China (Zhu *et al.,* 2014).

Our study revealed that *Salmonella* Anatum was isolated from the chicken's liver (Figure 1). Nearly similar results were obtained by Abd-Elghany *et al.* (2015) where *S.* Anatum was detected 4.8% from chicken liver. Slightly higher results were recorded by Al-Abadi *et al.* (2011) and Molla *et al.* (2003), who could isolate *S.* Anatum from the chicken liver in a percentage of 8% and 12.9% respectively.

Nevertheless, our finding was lesser than that achieved by Elmonir *et al.* (2017) who summarized that the incidence rate of *Salmonella* in the chicken liver was 20%. Also, Zhao *et al.* (2017) described that *Salmonella* recovered from the chicken liver in a percentage of 32%. Furthermore, El Sayed *et al.,* (2016) found that *S.* Anatum was detected in different internal organs of broiler chickens such as the intestine (35%), liver (23%), spleen (16%), heart (14%), and yolk sac (12%).

It is worthy to mention that, *S.* Anatum could be detected in a percentage of 3.33% (Habashy *et al.,* 2021), 2% (Gad *et al.*, 2018), and 2% (Abd-Elghany *et al.*, 2015) from chicken meat samples. In addition, a higher percentage (14.6%) was stated by Mezali *et al.(* 2012) for poultry meat. Thai *et al.* (2012) found that *S.* Anatum was the most prevalent serotype isolated from chicken meat in north Vietnam with an incidence of 15.8%.In another research, *S.* Anatum was detected sporadically with a prevalence rate of 0.02% (Witkowska *et al.,* 2018) and the such finding was lower than the obtained result in our study.

Although the water used in washing and chilling employed throughout the processing steps have a cleaning effect that reduces the bacterial loads, it can also encourage cross-contamination across carcasses (GöKsoy *et al.,* 2004, Russell, 2008). Consequently, chicken carcasses may be contaminated either with various spoilage or pathogenic microbes. In our investigation, *Salmonella* spp. could not be isolated from any of the samples of washing water that were examined. However, *Salmonella* was detected in 0.8% of washing water at different slaughterhouses (Giombelli *et al.,* 2015). However, Hamidi *et al.* (2014) detected *Salmonella* spp. in washing water with an incidence of 10.9%. Scalding water temperature could affect or kill many pathogens and microorganisms, which is a critical step. However, this temperature may be insufficient to kill thermophiles (Firildak *et al.,* 2015). Our result could be attributed to the uncontrolled and elevated scalding water temperature used in small-scale poultry processing plants.

The chromosomally positioned *invA* gene enables the quick and accurate recognition of Every reported *Salmonella* serotype by PCR (Eng *et al.,* 2015, Mubarak *et al.,* 2022). Additionally, for the genus to invade host epithelial cells, the *invA* gene must be present (Fàbrega *et al.,* 2013). Primer sequences were used for the identification of the *invA* marker gene listed in (Table 1). Many studies from many nations have exploited the *invA* gene as a quick, accurate, and affordable indicator for the genetic verification of *Salmonella* species derived from chicken origins, including, Egypt (Elshebrawy *et al.,* 2022), Iraq (Harb *et al.,* 2018), Turkey (Cunningham *et al.,* 2022), and South Africa (Ramtahal *et al.,* 2022).

Salmonella is one example of a multidrug-resistant (MDR) bacterium that has emerged as a result of the extensive utilization of antibacterial drugs in both human and animal medicine for improving growth, prevention, and treatments (Harb *et al.,* 2018, Catry *et al.,* 2015). In our study, *S.* Anatum showed resistance to ten antimicrobial agents among six antimicrobial classes. Additionally, *S.* Anatum showed resistance to chloramphenicol and tetracycline, they are regarded as the conventional first-line medications frequently used to treat salmonellosis. This pattern of resistance is consistent with that seen in other investigations carried out in South Africa (Phosa *et al.,* 2022), China (Li *et al.,* 2019), and Iraq (Harb *et al.,* 2018).

Aminoglycosides are a member of the antibacterial drugs that are most frequently used to treat various diseases in both animals and people. In the current study, *S.* Anatum exhibited resistance to gentamicin, it is regarded as a crucial drug agent for regular surveillance systems for resistance of *Salmonella* species (Garcia-Migura *et al.,* 2014). This pattern of resistance is congruent with what has been observed in other investigations (Li *et al.,* 2019) as well as in (Harb *et al.,* 2018).

S. Anatum exhibited a high resistance rate towards cefotaxime, ceftriaxone, and ceftazidime(third-generation cephalosporin), This resistance pattern is compatible with results from a related study where *Salmonella*

has been recovered and isolated from chicken carcasses in South Africa (Mokgophi *et al.,* 2021), China (Yue *et al.,* 2020), and Iraq (Harb *et al.,* 2018). The misuse of antibiotics for treatments, protection, and improvement of growth in chicken farming may be the cause of the greater resistance rates for ceftazidime, cefotaxime, and ceftriaxone in this research. It is noteworthy that, the preferred medications for treating virulent non-typhoidal *Salmonella* poisoning in human beings, particularly in children and the elderly, are fluoroquinolones and third-generation cephalosporins. *Salmonella* strains have been detected in chicken carcasses that have developed a resistance to cefotaxime should raise the public health alarm (Andoh *et al.,* 2017).

Interestingly, examined *S.* Anatum was resistant to ciprofloxacin (second-generation quinolones). Likewise, ciprofloxacin was ineffective against *Salmonella enterica* serotypes obtained from various poultry species in India (Mir *et al.,* 2015). Also, Li *et al.* (2022) reported a consistent pattern of resistance to ciprofloxacin among *Salmonella enterica* serotype isolates obtained from whole poultry carcasses in China. In contrast, in Brazil, *Salmonella enterica* serotypes separated from chicken carcasses were susceptible to ciprofloxacin (Panzenhagen *et al.,* 2016). The widescale evolution of MDR *Salmonella* serotypes recovered from various food of animal sources showed resistance to both the first line of conventional antibacterial drugs as well as important clinical antimicrobial agents such as extended-spectrum cephalosporins and fluoroquinolones pose a serious risk to the general health due to the possibility of their transmitted to people. To safeguard the general public health, antimicrobial drugs must be used in chicken and animal husbandry in a reasonable manner. Besides, it is necessary to set up surveillance programs to track the usage of antibiotics in developing nations to protect global health from the development of illnesses that are resistant to antibiotics.

CONCLUSION

This study revealed that *S.* Anatum serovar was found at a percentage of 2.2% in Cairo and Giza markets in Egypt. However, *Salmonella* spp. failed to be isolated from washing water used in small-scale poultry processing abattoirs. The isolated serovar exhibits a multidrug-resistant (MDR) character to aminoglycosides, third-generation cephalosporins, and fluoroquinolones. The detected *S.* Anatum serovar displayed resistance to both cefotaxime and ciprofloxacin, which are regarded as the standard antibiotic agents for treating *Salmonella* poisoning in humans. Such results may indicate a hazard to human beings either through cross-contamination or if raw and undercooked livers are consumed. To stop the transmission of *Salmonella* serotypes and lower the possibility of infection in humans, our research also highlighted the necessity to implement continuous monitoring systems, and Hazard Analysis Critical Control Point (HACCP) programs at each level of the manufacturing and production process. The reasonable use of antibacterial medicines in both human and animal medicine is essential to safeguard global health against the spread of multidrug-resistant bacteria. Furthermore, greater research is needed into the antibiotic susceptibility patterns of *Salmonella* serotypes derived from purchased chicken carcasses and giblets in the marketplaces of Egypt.

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مدي التواجد والمقاومة للمضادات الميكروبية للسالمونيلا المعزولة من كبد الدجاج وماء الغسيل المستخدم في مجازر الدواجن صغيرة الحجم

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هدفت هذه الدراسة إلى تحديد تواجد وتوصيف السالمونيلا غير التيفودية في كبد الدجاج والماء المستخدم في غسيل ذبائح الدجاج. وفي هذا الصدد تم جمع ٥٥ عينة شملت (٤٥ كبد دجاج ، و ١٠ ماء غسيل) من عدة متاجر ومصانع تجهيزالدواجن الصغيرة الحجم المتواجدة في القاهرة والجيزة بجمهورية مصرالعربية. حيث أظهرت النتائج تواجد السالمونيلا اناتم بنسبة ٢,٢٪ (١/٤٥) في كبد الدجاج، ولم يتم عزل السالمونيلا من ماء الغسيل. وكانت السلالة المعزولة هي سالمونيلا اناتم ومن خلال التحديد والتعريف الجزيئي لجينات الضراوة للسالمونيلا وجد انها تضمنت جين الضراوة الكروموسومية *invA* والذي قد يلعب دورًا مهمًا في آلية مقاومة السالمونيلا للمضادات الحيوية. كذلك تم فحص مقاومة معزولة السالمونيلا اناتم لأهم المضادات الميكروبية المستخدمة في العلاج البشري وصناعة الدواجن وذلك باستخدام اختبارالحساسية، وقد أظهرت النتائج أن لديها مقاومة لجميع المضادات الميكروبية التي تم فحصها باستثناء أميكاسين ، أزيثروميسين، حمض ناليديكسيك، سلفاميثوكسازول، تريميثوبريم، سيفوكسيتين، ميروبينيم، إرتابينيم، وكوليستين. وبذلك توضح الدراسة دور اكباد الدجاج في التلوث وانتقال السالمونيلا المقاومة لمضادات الميكروبات إلى السلسلة الغذائية للانسان مما يتسبب في مخاطر صحية عالمية.