Impact of cooking methods of meat on antibiotic residues: Review

Gowtham P, Muthukumar M, Eswara Rao B, Kalpana S, Keerthika V and Dani Nishant JMA

Abstract

Antibiotics are the most conventionally used veterinary drug for raising food animals. They are used so, to ward off the undesirable effects generated by the multiple infectious pathogens. It helps to maintain the optimum level of production in farm animals without falling ill. The consequences faced with the use of drugs lead to the generation of antibiotic residues in the food products, consumed by the public. These residues will put forth a complication to the health of humans when it exceeds above the limit of the Maximum residues limit (MRL). The presence of antibiotic residues in animal-derived foods is one of the major causes of the development of antibiotic resistance in human pathogens. To overcome the antibiotic residues in food products nowadays lots of researches going on besides that, several methods of cooking like frying, boiling, roasting, grilling, etc., are also known to have reduced the level of antibiotic and other drug residues in the meat products. In this paper, we explore some antibiotic residues in meat and meat products and their reduction levels while applying several cooking methods.

Keywords: Antibiotic residues, cooking methods, withdrawal period, maximum residual level, tolerable limit

Introduction

Meat from the food animals is a valuable source of protein, minerals, and other nutrients and widely accepted as one of important food products, worldwide. Rising non-vegetarianism is generally due to increased income and the subsequent diversification of diets for better and greater protein intake (Muthukumar et al., 2017) [33]. Owing to the expanding population of the human race, food production needs to be increased. To satisfy this emerging demand for the production of meat and its allied products, greater enhancements in production and productivity are expected day by day. The goal of achieving production of increased quantity of meat, egg, or milk at the lower cost led to the intensive animal production, where animals and birds are confined at high stocking density to ensure greater output with lowest input (Gliessman 2015) [11]. The modern integrated and intensified poultry/livestock production necessitates the use of several agrochemicals, especially antibiotics and other veterinary drugs to contain the diseases, enhance growth promotion for producing food commodities as cheaply and efficiently as possible to meet demands of an ever expanding world population (Maged and Hamdley, 2006 [27], Muthukumar and Mandal, 2017) [30]. However, indiscriminate use of veterinary drugs and antimicrobials in livestock/poultry without following required withdrawal periods leads to accumulation of their residues in the tissues and organs of treated poultry/livestock and eventually become part of the human food chain. Residues of antibiotics remaining in animal-derived human foods may pose potential human health hazards toxicologically, microbiologically or immuno-pathologically. The matter therefore, assumes greater significance to monitor the presence of these residues in meat at regular intervals to ensure that public health is not compromised by violate residues (Noel et al., 2005) [35]. The presence of these residues above the permissible level is also a major bottleneck in the acceptance of food commodities by the importing countries. The importing countries impose legal restrictions with respect to residues in the food. Concerning international trade and consumer trust, residues of drugs, and/or their prospective metabolites in animal derived-foods are significant (Kalpana et al., 2012) [23].
Poultry industry
The meat production from poultry is 4.06 million tonnes which contribute about 50% of the total meat production in India (8.11 million tonnes) (BAHS, 2019) [3]. Antibiotics are used, notably in broilers, for disease prevention which in turn indirectly helps to accelerate the growth. It can increase the rate of growth through various means, such as thinning of mucous membranes in the gut to promote absorption, enhancing intestinal motility, facilitating an ideal environment for beneficial gut flora through the destruction of pathogenic organisms, suppressing cytokine for better muscle growth (Nisha, 2008) [34]. The worldwide annual average intake of antimicrobials per kilogram of raised animals is 172 mg/kg, 148 mg/kg, and 45 mg/kg for pigs, chicken, and beef respectively. The global antimicrobial consumption will increase by 67% between 2010 and 2030, from 63,151 ± 1,560 tonnes to 105,596 ± 3,605 tonnes (Van Boeckel et al., 2015) [46].

Impacts of residues on public health
The antibiotic residues from the food animals affect health in several ways. The direct sequel on the health of consumers includes bone marrow toxicity (chloramphenicol), nephropathy (gentamicin), reproductive disorders, allergy, or hypersensitivity reactions (beta-lactam antibiotics), etc. (Goulette, 2007) [14]. Another sequel will be the indirect effect owing to the emergence of antibiotic resistance (Glynn et al., 1998 [12]; Butaye et al., 2001) [5]. It is worrying that these estimates will be more than 10 million by 2050 than the current figure of 700,000 individuals losing their life to antimicrobial resistance fight each year by 2050. Besides, antimicrobial resistance is becoming the reason that people suffer more than the overall victims of cancer and road accidents (O’Neill, 2014) [36]. An increased risk of colon cancer (first and middle portions) is associated with the penicillin class of drugs, whereas tetracycline is associated with cancer in the last segment of the colon (Lo et al., 2002) [25]. Continuous ingestion of meat or meat products contaminated with toxic drug residues induces biotransformation changes of endogenous and exogenous compounds, resulting in several health issues, namely neurological disorders, carcinomas, and endocrine dysfunction (Muthukumar and Mandal, 2017) [30].

Table 1: Level of antibiotic residues in animal products

| Antibiotic          | Specimen             | Residue level (ppb) | Reference          |
|---------------------|----------------------|---------------------|--------------------|
| Ciprofloxacin       | Chicken muscle       | 89.60               | Ramatla et al., 2017 [199] |
|                     | Chicken liver        | 152.20              |                    |
|                     | Cattle muscle        | 89.60               |                    |
|                     | Cattle liver         | 145.20              |                    |
|                     | Cattle Kidney        | 98.20               |                    |
|                     | Pig muscle           | 42.60               |                    |
|                     | Pig liver            | 220.00              |                    |
|                     | Pig Kidney           | 72.50               |                    |
| Chloramphenicol     | Chicken              | 12.64-226.62        | Yibar et al., 2011 [198] |
| Enrofloxacin        | Chicken liver        | 10-10690            | Sultan, 2014 [199] |
| Tetracycline        | Cattle liver         | 30                  | Ramatla et al., 2017 [199] |
|                     | Sheep liver          | 20                  |                    |
|                     | Cattle muscle        | 46.8-220.2          |                    |
|                     | Cattle - tissue      | 176.3               |                    |
|                     | Diaphragm            | 96.8                | Abbasi et al., 2012 [11] |
|                     | Kidney               | 672.40              |                    |
| Oxytetracycline     | Cured meat           | 42-360              | Senyuva et al., 2000 [193] |
| Sulphonamides       | Chicken muscle       | 35.2-81.6           | Ramatla et al., 2017 [199] |
|                     | Chicken liver        | 20.7-65.9           |                    |
|                     | Pig liver            | 48.20-69.90         |                    |
|                     | Pig-kidney           | 52.80-92.80         |                    |
|                     | Chicken-muscle       | 0.02-0.8            | Mehta, 2012 [180]  |
| Doxycycline         | Chicken-muscle       | 847.7               | Jank et al., 2017 [151] |
| Streptomycin        | Chicken-muscle       | 98.44-452.90        |                    |
|                     | Cattle-muscle        | 625.90-989.20       | Ramatla et al., 2017 [199] |
|                     | Pig-muscle           | 620.30-875.80       |                    |

R- Residue level in Raw meat (µg/kg), C- Residue level in Cooked (µg/kg), R%- Reduction % in residue level, C%-change in residue %, B- boiling, Br- barbecuing, R- roasting, G- grilling, M- microwaving, F –Freezing, N- sample size

Enrofloxacin
Enrofloxacin belongs to a potent class of antibiotics (fluoroquinolone) that are prevalently used in veterinary and human medicine. They are effective against gram-positive, gram-negative, and Mycoplasma organisms. Fluoroquinolone exhibits concentration-dependent effects, i.e., depending on the concentration of the drug, the duration, and intensity of bacterial lysis takes place. (Kalpana et al., 2015) [24]. Quinolones are very stable during thermal procedures, with almost no results obtained even by heating to ultra-high temperatures (shaltout et al., 2019) [44]. Enrofloxacin residues are not affected by cooking procedures however, an apparent decrease in enrofloxacin concentration is observed as some of the liquid used for cooking (boiling and frying) was lost by exudation. In contrast, an apparent increase in residue concentration is observed in a water-loss cooking technique (roasting and grilling) (Lolo et al., 2006) [15]. Frying is an effective way of reducing enrofloxacin residue concentrations in chicken meat (Hassan et al., 2019) [16].
Cooking methods, such as boiling, grilling, and roasting, have been shown to greatly reduce the ciprofloxacin residue (Hasanen et al., 2016 [15]; Gogoi and Roy, 2019) [13]), still freezing is the efficient method to degrade ciprofloxacin residues to a safe level than microwaving (Fahim, 2019 [8]; Shaltout et al., 2019) [48].

Ciprofloxacin

Ciprofloxacin also belongs to fluoroquinolones, which are reported to be a group of synthetic antimicrobial agents that are highly effective against diverse microbial infections having a broad range of actions. They are known to act by inhibiting DNA gyrase, which during cell division affecting the stability of the bacterial DNA molecule’s DNA configuration. These are widely used in humans to treat urinary tract and enteric infections. It is primarily used in farm animals for the treatment and prevention of infectious diseases. The heat treatment methods of boiling, grilling, and roasting do not affect the degradation of ciprofloxacin residues. As ciprofloxacin is a heat-stable compound that gets degrade less by the heat treatment process, microwaving and freezing will greatly reduce the ciprofloxacin residue (Hasanen et al., 2016 [15]; Gogoi and Roy, 2019) [13]) still freezing is the efficient method to degrade ciprofloxacin residues to a safe level than microwaving (Fahim, 2019 [8]; Shaltout et al., 2019) [48].

Sulfonamides

Sulfonamides are considered the synthetic antimicrobial agents acting as competitive dihydropteroate synthetase enzyme inhibitors. They are used to treat several gastrointestinal and urinary tract infections (Igwe and Okoro, 2014) [19].

Autoclaving of the incurred piglet muscle tissue results in a maximum reduction (29.6%) of sulfamethazine followed by the boiling (18%), while the microwave (15%) is the least significant (Papapanagiotou et al., 2005) [17]. Fish fillets when cooked at 190 °C contributed to an average 54.0 percent decrease in ormetoprim and a 46.1 percent decrease in sulfadimethoxine (Xu et al., 1996) [48].

Sulfonamide reduction has a greater effect on the time duration factor (9, 6, and 3 min) than the deep frying temperature of chicken meatballs (170, 180, and 190 °C). For sulfafloxinoxaline, sulfamethazine, sulfadiazone, sulfamethoxazole respectively, the maximum reductions obtained are 27.6, 27.5, 37.5, and 40.7 percent (Ismail-Fity et al., 2008) [20]. Similarly in chicken meatballs, residues of sulfadiazine, sulfaufoxinolazone, sulfanomethoxine, and sulfamethoxazole results in decreased residue levels in boiling (45-61%), roasting (38-40%), and microwaving (35-41%) (Furasawa and Hanabusu, 2002) [10].

Tyllosin

Tyllosin, a macrolide group of antibiotics (broad-spectrum), has a specific action on *Mycoplasma* species. It is a combination of four macrolide antibiotics (Tyllosin-A, B, C, D) formed by *Streptomycyes fradiae*. Cooking methods,
cooking temperature and length, and concentration of tylosin before processing are the factors that influenced tylosin residue in chicken meatballs during cooking. The overall decrease in tylosin will be 35.3 percent during microwave treatment (2 minutes) and 79.9 percent during boiling (30 minutes). By limiting the use of meat juice, tylosin residues might be minimized (Salaramoli et al., 2016) [22].

### Tetracyclines

Tetracyclines are considered as the major antibiotics used, including oxytetracycline (OTC), chlortetracycline (CTC), tetracycline (TC), doxycycline (DOC). They are affordable and reported to have a broad spectrum of activity to Gram-positive and negative organisms. Usually, veterinarians recommend them for medicinal, prophylaxis, and growth promotion purposes in chicken and livestock by injections, feedstuffs, or drinking water. They are recommended for use in a wide variety of livestock, including chicken (Nguyen et al., 2013) [33].

Boiling is more effective in decreasing the concentration of OTC in muscle, while roasting was more effective in decreasing the concentration of broiler bird liver samples (Vivienne et al., 2018) [47]. In water, OTC is found to be less temperature-stable than in cooking oil (Rose et al., 1996) [40]. Baking at 145 °C (20 minutes) will be enough to kill almost 55 percent of the initial amount of TC residues in chicken, (Said and Salma, 2019) [41]. The cooking process, time, and temperature can play a significant role in reducing TC antibiotic residue while cooking food among the different agents affecting antibiotic residue after the cooking process (Javadi, 2011) [22].

### Miscellaneous residues – Anthelmintic drugs

In the prophylaxis and treatment of endoparasitic and ectoparasitic infestations, a diverse range of anthelmintic drugs is being used in livestock. Different benzimidazole compounds (fenbendazole, triclabendazole, mebendazole, and albendazole), imidazothiazoles (levamisole), macrocyclic lactones (ivermectin) are used to manage nematode, cestode, and trematode infestations. Anthelmintic drug residues are generally resistant to degradation during shallow frying and roasting. Traditional cooking cannot be regarded as a precaution against the ingestion of veterinary anthelmintic drug residues in beef (Cooper et al., 2011) [7].

#### Table 4: Impact of cooking methods on tetracyclines residues

| Sample          | N  | Oxycycline   | References          |
|-----------------|----|--------------|---------------------|
|                 |    | R | C | R% |                           |
| Lamb            | 2  | 6470 | 330 (B) | 95 | Ibrahim, 1994 [18]        |
|                 |    |    | 5690 | 4700 (F) | 17.3 |
| Chicken         | 3  | 1914 | 294 (B) | 84.6 | Abou-Raya et al., 2013 [22] |
|                 |    |    | 1790 | 18 (M) | 99 |
|                 |    |    | 1650 | 89 (R) | 94.6 |
| Chicken         | 120 | 446.16 | 69.04 (B) | 84.52 | Elbagory et al., 2016 [7] |
|                 |    |    |     | 28.46 (F) | 93.62 |
|                 |    |    |     | 15.25 (G) | 96.58 |
| Chicken         | 3  | 3.81 | 2.47 (B) | 35.17 | Hussein, 2016 [17]        |
|                 |    |    | 1.96 (F) | 48.55 | |
|                 |    |    | 0.98 (M) | 74.27 | |
| Chicken Thigh   | 40 | 11190 | 4585 (B) | 59 | Nashwa, 2016 [32]        |
|                 |    |    | 6592 (R) | 41.1 | |
|                 |    |    | 2142 (M) | 80.9 | |
| Chicken Breast  | 4194 | 2392 (B) | 42.3 | | |
|                 |    |    | 3297 (R) | 31.4 | |
|                 |    |    | 1032 (M) | 75.4 | |
| Beef            | 60 | 322.2 | 71.10 (B) | 77.9 | Mgonja et al., 2018 [29] |
|                 |    |    | 93.7 (Br) | 70.9 | |
| Rabbit Meat     | 3  | 27.2 | 3.27 (B) | 87.97 | Fahim, 2019 [9]          |
|                 |    |    | 3.54 (M) | 86.95 | |
|                 |    |    | 7.07 (R) | 73.98 | |
| Chicken         | 45 | 244 | 55.84 (B) | 77.93 | Shaltout et al., 2019 [44] |
|                 |    |    | 45.2 (M) | 81.48 | |
|                 |    |    | 91.29 (R) | 37.41 | |
|                 |    |    | 239 (F) | 2.05 | |

#### Table 5: Impact of cooking methods on tilmicosin residues

| Sample          | N  | Tilmicosin   | References          |
|-----------------|----|--------------|---------------------|
|                 |    | R | C | R% |                           |
| Chicken Thigh   | 3  | 1.45 | 0.92 (B) | 36.5 | Hussein et al., 2016 [17] |
|                 |    |    | 0.78 (F) | 46.4 | |
|                 |    |    | 0.86 (M) | 0.86 | |

#### Table 6: Impact of cooking methods on ampicillin residues

| Sample          | N  | Ampicillin | References          |
|-----------------|----|-----------|---------------------|
|                 |    | R | C | R% |                           |
| Chicken         | 120 | 253.7 | 47.6 (B) | 81.2 | Elbagory et al., 2016 [7] |
|                 |    |    | 24.10 (F) | 90.5 | |
|                 |    |    | 13.9 (M) | 94.5 | |

---

"306"
Table 7: Impact of cooking methods on gentamicin residues

| Sample       | N | R       | C       | R%     | References   |
|--------------|---|---------|---------|--------|--------------|
| Chicken Thigh| 3 | 2.56    | 1.64 (B)| 35.9   | Hussein et al., 2016 [17] |
|              |   |         | 1.29 (F)| 49.6   |              |
|              |   |         | 1.12 (M)| 56.2   |              |

Reason for the reduction of antibiotic residues level in cooked meat
Transfer of antibiotic residues from the muscle to the boiling water and loss of juices that come from the muscle as it is roasted may explain the reduction of antibiotic residue after different cooking techniques. (Furusawa and Hanabusa, 2002 [10]; Lolo et al., 2006 [26]; Nguyen et al., 2013 [13]; Shaltout et al., 2019 [44]; Javadi, 2011) [22]. Cooking methods cannot guarantee the complete removal of the drugs found in meat and can only reduce the concentrations of these drug residues to a safer level. By discarding any juices that come from the edible tissues as they are cooked, exposure to antibiotic residues can be minimized (Javadi, 2011) [22].

Strategies to turn down the antibiotic residues
The first and foremost step is to create awareness among individuals and organizations by the way of education through veterinary personnel, literature, and government authorities. System for national control and monitoring of the use, resistance, and residues of veterinary antibiotics need to be carried out. The analysis, grading, and forbidding of product possessing residues, exceeding the Maximum residues limit (MRL) is done by adopting rapid screening procedures (Nisha, 2008 [34]; Muthukumar and Mandal, 2017 [30]; Biswas et al., 2019) [4]. Antibiotics use should be avoided before the slaughter of animals, if necessary arise withdrawal period recommended for the specific antibiotics should be strictly followed. Avoid the use of broad-spectrum and long-acting antibiotics as a growth promoter in food animals. Further sub-therapeutic and overdose of antibiotics to be avoided. Use of drugs with a minimal withdrawal period in food animals is recommended.

Fig 1: Flow chart indicating the effects of different cooking methods on the level of antibiotic residues

Table 8: Tolerable limits of antibiotic residues in meat (FSSAI 2011) [9]

| S. No. | Antibiotics                  | Tolerance limit (mg/kg) in meat |
|--------|------------------------------|---------------------------------|
| 1      | Ampicillin                   | 0.01                            |
| 2      | Cloxacillin                  | 0.01                            |
| 3      | Chlortetracycline/Oxytetracycline/Tetracycline | 0.2 |
| 4      | Erythromycin                 | 0.1                             |
| 5      | Trimethoprim                 | 0.01                            |
| 6      | Enrofloxacin                 | 0.01                            |
| 7      | Tilmicosin                   | 0.15                            |
| 8      | Monensin                     | 0.01                            |
| 9      | Tylosin                      | 0.1                             |
| 10     | Meloxicam                    | 0.01                            |
| 11     | Sulphadiazine                | 0.01                            |
| 12     | Flunixin Meglumine           | 0.01                            |

(Prescott and Baggot, 1993) [38]
Table 9: Withdrawal period for various antibiotics in food animals

| Antimicrobials         | Withdrawal time before slaughter (Days) |
|------------------------|----------------------------------------|
|                        | Chicken/ poultry | Swine | Sheep | Cattle |
| Amoxicillin            | -              | 15    | -     | 06     |
| Ampicillin             | -              | -     | -     | 25     |
| Oxytetracycline        | 05             | -     | 28    | -      |
| Chlorotetracycline     | 01             | 0     | 0     | 10     |
| Tylosin                | 03             | 14    | -     | 21     |
| Procaine penicillin G  | 05             | 28    | 9     | 10     |
| Sulfamethazine         | -              | 15    | -     | 07     |

Conclusion
In food-producing animals, the use of antibiotics has the potential to generate residues in animal-derived products and creates a health threat to the consumer. The most likely cause for drug residues could be human handling, such as inappropriate use of antibiotics and illegal drug applications, and not comply with the withdrawal period. The residues present in the food materials are mainly influenced by the parameters like the nature of the drug (heat-stable or liable), its residue level in raw meat, cooking method, time, and temperature. It is recommended to properly screen the raw meat for antibiotic residues before food processing. There will be a need for new diagnostic tests to monitor antibiotic residues and to develop new antimicrobials or antibiotics. The use of eubiotics, probiotics, prebiotics, organic acids, and essential oils can be an alternative option to antibiotics and can be promoted. The development of organic production of food animals can be a protective means of eliminating antibiotic residues in meat.

References
1. Abbasi MM, Nemati M, Babaei H, Ansarin M, Nourdadgar AO. Solid-phase extraction and simultaneous determination of tetracycline residues in edible cattle tissues using an HPLC-FL method. Iranian Journal of pharmaceutical research: IJPR 2012;11(3):781.
2. Abou-Rayaa SH, Shalaby AR, Salama NA, Emam WH, Mehaya FM. Effect of ordinary cooking procedures on tetracycline residues in chicken meat. Journal Food Drug Analysis 2013;21(1).
3. Basic Animal Husbandry Statistics Annual Report-2019. BAHS 2019.
4. Biswas S, Banerjee R, Das AK, Muthukumar M, Naveena B, Biswas O et al. Antibiotic residues in meat products and public health importance in the perspective of drug resistance. Indian J Anim Hlth 2019;58(2):87-104.
5. Butaye P, Devriese LA, Haesbrouck F. Differences in Antibiotic Resistance Patterns of Enterococcus faecalis and Enterococcus faecium Strains Isolated from Farm and Pet Animals. Antimicrobial agents and chemotherapy 2001;45(5):1374-1378.
6. Cooper KM, Whelan M, Danaher M, Kennedy DG. Stability during cooking of anthelmintic veterinary drug residues in beef. Food Additives and Contaminants 2011;28(2):155-165.
7. Elbagory AM, Yasin NA, Algazier EA. Effect of Various Cooking Methods on Some Antibacterial Residues in Imported and Local Frozen Dressed Broilers and their Giblets in Egypt. Nutr Food Technol 2016;2(3).
8. Fahim HM. Evaluate antibiotic residues in beef and effect of cooking and freezing on it. Benha Veterinary Medical Journal 2019;36(2):109-116.
9. Food safety and standards (contaminants, toxins, and residues) regulations 2011. https://archive.fssai.gov.in/da/m/jcr:592f0e4-6897-44a4-b28e-5d9f0955c77/Compendium_Contaminants_Regulations_20_05_2019.pdf
10. Furusawa N, Hanabusa R. Cooking effects on sulfonamide residues in the chicken thigh muscle. Food research international 2002;35(1):37-42.
11. Gliessman SA. Global vision for food system transformation. Agriculture and Sustainable Food Systems 2015;39:725-726.
12. Glynn MK, Bopp C, Dewitt W, Dabney P, Mokhtar M, Angulo FJ. Emergence of Multidrug-Resistant Salmonella enterica serotype Typhimurium DT104 Infections in the United States. New England Journal of Medicine 1998;338(19):1333-1339.
13. Gogoi R, Roy DC. Effect of cooking on ciprofloxacin level in chicken meat. The Pharma Innovation Journal 2019;8(5):208-210.
14. Goulette RR. Investigation of Safe-Level Testing for Beta-lactam, Sulfonamide, and Tetracycline Residues in Commingled Bovine Milk. Pell Scholars and Senior Theses, Salve Regina University 2007.
15. Hasanen FS, Mohammed MM, Hassan WM, Amro FH. Ciprofloxacin residues in chicken and turkey carcasses. Benha Veterinary Medical Journal 2016;31(2):136-143.
16. Hassan MA, Amin R, Abol Elroso N. Enrofloxacin residues in chicken meat and giblet. Benha Veterinary Medical Journal 2019;36(1):175-183.
17. Hussein MA, Ahmed MM, Morshed AM. Effect of cooking methods on some antibiotic residues in chicken meat. Japanese Journal of Veterinary Research 2016;64(2):225-231.
18. Ibrahim A, Moats WA. Effect of cooking procedures on oxytetracycline residues in lamb muscle. Journal of agricultural and food chemistry 1994;42(11):2561-2563.
19. Igwe CN, Okoro UC. Synthesis, characterization, and evaluation for antibacterial and antifungal activities of n-heteroaryl substituted benzene sulphonamides. Organic Chemistry International 2014.
20. Ismail-Fitry MR, Jinap S, Jamilah B, Saleha AA. Effect of deep-frying at different temperature and time on sulfonamide residues in chicken meat-balls. J Food Drug Anal 2008;16:81-86.
21. Jank L, Martins MT, Arsand JB, Mota TMC, Feijo TC, dos Santos Castilhos T et al. Liquid chromatography–tandem mass spectrometry multiclass method for 46 antibiotics residues in milk and meat: development and validation. Food Analytical Methods 2017;10(7):2152-2164.
22. Javadi A. Effect of roasting, boiling and microwaving cooking method on doxycycline residues in edible tissues of poultry by microbial method. African Journal of Pharmacy and Pharmacology 2011;5(8):1034-1037.
23. Kalpana S, Aggarwal M, Rao GS, Malik JK. Effects of aflatoxin B1 on tissue residues of enrofloxacin and its metabolite ciprofloxacin in broiler chickens. Environmental Toxicology and Pharmacology 2012;33(2):121-126.
24. Kalpana S, Rao GS, Malik JK. Impact of aflatoxin B1 on the pharmacokinetic disposition of enrofloxacin in broiler chickens. Environmental Toxicology and Pharmacology
25. Lo WY, Friedman JM. Teratogenicity of recently introduced medications in human pregnancy. Obstetrics & Gynecology 2002;100(3):465–473.
26. Lolo M, Pedreira S, Miranda JM, Vázquez BI, Franco CM, Cepeda A, Fente C. Effect of cooking on enrofloxacin residues in chicken tissue. Food additives and contaminants 2006;23(10):988–993.
27. Maged O, Hamdey E. The analysis of the livestock industry frame in Egypt: proposal in the light of bird flu crisis. IDSC: Ministerial Cabinet Information and Designing Making Supporting Center: report 2006;29(5).
28. Mehtabuddin A, Ahmad T, Nadeem S, Tanveer Z, Arshad J. Sulfonamide residues determination in commercial poultry meat and eggs. J Anim Plant Sci 2012;22(2):473–478.
29. Mgonja F, Mosha R, Mabiki F, Choongo K. Effect of heat treatment on oxytetracycline residues in beef. American Journal of Research Communication 2015;7(6):1-13.
30. Muthukumar M, Mandal PK. Concerns and consequences of industrial livestock and meat production. Journal of Meat Science 2017;12(2):1-9.
31. Muthukumar M, Ramesh M, Naveena BM, Kulkarni VV. Consumption pattern and purchase behavior of meat consumers in India. J Vet Pub Hlth 2017;15(2):103-111.
32. Nashwa MZ, Arwa HN, Saleh S, Nahla SL. Experimental study on the effect of different cooking methods of oxytetracycline residues in chicken meat. Egypt J Chem Environ Health 2016;2(2):598-610.
33. Nguyen V, Li M, Khan MA, Li C, Zhou G. Effect of cooking methods on tetracycline residues in pig meat. African Journal of Pharmacy and Pharmacology 2013;7(22):1448-1454.
34. Nisha AR. Antibiotics residues A global health hazard. Vet World 2008;1(12):375-377.
35. Noel C, Dufernez F, Gerbod D, Edgcumb VP, Delgado-Viscogliosi P, Ho LC, et al. Molecular phylogenies of Blastocystis isolates from different hosts: implications for genetic diversity, identification of species, and zoonosis. Journal of clinical microbiology 2005;43(1):348-355.
36. O’Neill J. Antimicrobial resistance. Tackling a Crisis for the Health and Wealth of Nations 2014.
37. Papapanagiotou EP, Fletouris DJ, Psomas EI. Effect of various heat treatments and cold storage on sulfamethazine residues stability in incurred piglet muscle and cow milk samples. Analytica Chimica Acta 2005;529(1-2):305-309.
38. Prescott JF, Baggot JD. Antimicrobial Therapy in Veterinary Medicine. Ames, IA: Iowa State University Press, Ames, IA 1993, 250-525.
39. Ramatla T, Ngoma L, Adetunji M, Mwanza M. Evaluation of antibiotic residues in raw meat using different analytical methods. Antibiotics 2017;6(4):34.
40. Rose MD, Bygrave J, Farrington WH, Shearer G. The effect of cooking on veterinary drug residues in food: 4. Oxytetracycline. Food Additives & Contaminants 1996;13(3):275-286.
41. Said RM, Slama H. Effect of Cooking Temperature on Residual Oxytetracycline Hydrochloride in Cooked Chicken. Bulletin of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca. Animal Science and Biotechnologies 2019;76(1):35-42.
42. Salaramoli J, Heshmati A, Kamkar A, Hassan J. Effect of cooking procedures on tylosin residues in chicken meatball. Journal fur Verbraucherschutz und Lebensmittelsicherheit 2016;11(1):53-60.
43. Senyuva HZ, Ozden T, Sarica DY. High-performance liquid chromatographic determination of oxytetracycline residue in cured meat products. Turkish Journal of Chemistry 2000;24(4):395-400.
44. Shaltout FAE, Shatter MAE, Sayed NF. Impacts of Different Types of Cooking and Freezing on Antibiotic Residues in Chicken Meat. J Food Sci Nut 2019;5:045.
45. Sultan IA. Detection of enrofloxacin residue in livers of livestock animals obtained from a slaughterhouse in Mosul City. Journal of Veterinary Science and Technology 2014;5(2).
46. Van Boeckel TP, Brower C, Gilbert M, Gfenell BT, Levin SA, Robinson TP, et al. Global trends in antimicrobial use in food animals. Proceedings of the National Academy of Sciences 2015;112(18):5649-5654.
47. Vivienne EE, Josephine KO, Anaelom NJ. Effect of temperature (cooking and freezing) on the concentration of oxytetracycline residue in experimentally induced birds. Veterinary World 2018;11(2):167.
48. Xu D, Grizzle JM, Rogers WA, Santerre CR. Effect of cooking on residues of ormetoprim and sulfadimethoxine in the muscle of channel catfish. Food research international 1996;29(3-4):339-344.
49. Yibar A, Cetinkaya F, Soyutemiz GE. ELISA screening and liquid chromatography-tandem mass spectrometry confirmation of chloramphenicol residues in chicken muscle, and the validation of a confirmatory method by liquid chromatography-tandem mass spectrometry. Poultry science 2011;90(11):2619-2626.