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Profile of Antibiotic Residue and Antibiotic Resistance in Broiler Chicken Meat in Indonesia: Public Health Importance

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ABSTRAK

Keamanan pangan merupakan isu global dan menjadi perhatian bersama. Di bidang peternakan, penyalahgunaan antibiotik dalam praktik kesehatan hewan berdampak pada bahaya residu dan resistensi antimikroba pada produk pangan asal hewan bagi kesehatan masyarakat. Penelitian ini mengkaji profil residu dan resistensi antibiotik pada daging ayam broiler di Indonesia. Kajian dilakukan melalui tinjauan pustaka terhadap artikel penelitian yang dipublikasikan di jurnal ilmiah nasional dan internasional, prosiding seminar, dan laporan penelitian. Hasil penelitian mengungkapkan, dalam lima tahun terakhir (2018-2023) masih ditemukan residu antibiotik pada daging ayam broiler di beberapa daerah di Indonesia. Pada periode yang sama, resistensi antibiotik juga ditemukan pada sampel daging ayam broiler di beberapa wilayah Indonesia. Resistensi antibiotik yang ditemukan adalah pada satu jenis antibiotik dan beberapa jenis antibiotik (multidrug resistance) sekaligus. Temuan ini dapat dijadikan bahan evaluasi perbaikan manajemen rantai produksi dan distribusi produk daging ayam broiler dalam negeri tentang jaminan keamanan pangan asal hewan.

Kata kunci : daging ayam broiler; keamanan pangan; residu antibiotik; resistensi antibiotik

INTRODUCTION

The issue of food safety has been a global concern for a long time. Unsafe food hampers economic growth, with annual productivity losses of up to USD 95 billion in low- and middle-income countries (FAO, 2023). Unsafe food, containing harmful bacteria, viruses, parasites, chemicals, or physical contaminants, causes more than 200 diseases rangingfrom diarrhea to cancer. Over time, food contaminated with pesticides, or containing sub-therapeutic doses of antibiotics that build up in the human body, can cause chronic disease. Seventy percent of global cases of foodborne diseases are concentrated in sub-Saharan Africa

and South/Southeast Asia, and 40% of the burden falls on children under five years of age resulting in 125,000 deaths per year (Doumeizel, 2019).

One of the issues related to food safety in the livestock sector is the misuse of antibiotics in animal health practices which has an impact on dangerous residues and antimicrobial resistance. FAO (2023) in FAO's work on food safety: science, standards and good practices stated that allowing antimicrobials to become resistant to both antibiotics and other antimicrobials such as fungicides, is one of the most urgent public health threats today. Some antimicrobial infections can be transmitted through food. In addition to their use in human medicine, the use of antimicrobials in livestock, aquaculture, and crop production drives resistance, making diseases difficult or impossible to treat in humans, animals, and plants. Doumeizel (2019) stated that antimicrobials are one of the main causes of food-borne diseases. Low doses of antibiotics can affect the normal human intestinal flora and cause chronic diseases and the emergence of resistant pathogenic strains (Antimicrobial Resistance/AMR) in addition to overuse and abuse of veterinary and human drugs.

Chicken meat is one of the favorite sources of animal protein in Indonesia. According to Muaz *et al.* (2018), poultry farmers use disease-preventing antibiotics and growth promoters for faster chicken growth in the shortest possible time to increase the rate of feed assimilation and to reduce the incidence of death caused by pathogen attacks. These antibiotic residues in poultry meat have been found in many studies globally and are considered one of the possible causes of antibacterial resistance in human pathogens. Etikaningrum and Iwantoro (2017) in their study found that in the period 1993-2004 cases of antibiotic residues in poultry products in Indonesia with the range of antibiotic residues found in chicken meat was 8%-70%. Cases of antibiotic residues in poultry products were found in several areas with different types of antibiotics. In the same study, in 2011-2016 cases of antibiotic residues in Indonesia decreased, some studies even found no cases of antibiotic residues in poultry products, although some researchers still found tetracycline antibiotic residues in poultry products at small concentrations (4.1 and 4.17%). In this study, it was also discovered that cases of antibiotic residues in chicken liver were more numerous than cases of antibiotic residues in chicken meat (4.17%-83.3%).

The Indonesian government has regulated the use of antibiotics in livestock businesses by prohibiting the use of antibiotics as animal feed additives since 2009, but supervision over the sale of antibiotics is still weak. Farmers can still easily obtain antibiotics on the market. Unsupervised use of antibiotics is a challenge in itself. This is especially

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related to the dangers of antibiotic residues in food products of animal origin as well as antibiotic resistance which can endanger consumer health and the environment.

This paper aims to review the profile of antibiotic residue and resistance in broiler meat in Indonesia in the last five years (2018-2023). The profile of antibiotic residue and resistance in broiler meat in Indonesia will provide an overview regarding the management of antibiotic use in poultry farming as well as the practice of implementing hygiene and sanitation in the chicken meat production and distribution chain. It will further provide evaluation material for monitoring the use of antibiotics in the field.

MATERIAL AND METHODS

This article is a narrative literature review sourced from research related to antibiotic residues and antibiotic resistance in chicken meat in Indonesia during 2018-2023. Library references come from scientific articles published in national and international journals, research reports, and proceeding seminars which are accessed online via Google searching using several keywords, namely ‘residu antibiotika pada daging ayam di Indonesia jurnal’, ‘resistensi antibiotika pada daging ayam di Indonesia jurnal’, ‘antibiotic residue in chicken meat in Indonesia journal’, ‘antibiotic resistance in chicken meat in Indonesia journal’. Basedon existing keywords, there are 337 articles displayed. The articles were sorted again based on several criteria; original research article, broiler meat research subjects, research location in Indonesia, and research year 2018-2023 were published between 2018 and January 2024. A total of 32 articles were collected, consisting of 23 journal articles, three articles from proceedings, two from books, one from a research report, and three articles from protocols. Sample analysis descriptively.

RESULTS AND DISCUSSION

Antibiotic Residues

Meat can contain biological, chemical, and physical hazards. One of the chemical dangers that can be found in meat is the presence of antibiotic residue. As explained by Widiasih *et al.* (2020), the presence of antibiotics in food of animal origin needs to be monitored thoroughly from breeding, because some antimicrobials have the potential to pose health risks. The impact of antibiotic residues on food of animal origin can increase the potential threat to the human body's toxicological, microbiological, and immunological aspects. Among other things, it can be toxic to the liver, kidneys, and central

hemopoietic system, it can also disrupt the balance of microflora in the digestive tract and can trigger allergies. Currently, the dangers from the microbiological aspect of antibiotic residues are receiving increasing attention because antibiotic residues in food of animal origin have the potential to cause antibiotic-resistant pathogenic bacteria in consumers. Residues can cause resistance if they still have antibacterial activity (Rasbawati and Irmayani, 2018). Toxicological risks are mutagenic, namely genetic changes, teratogenic, and carcinogenic (Widhi and Saputra, 2021).

Antibiotics are chemical substances that can destroy or inhibit the growth of microorganisms. Antibiotics are often used for the prevention and treatment of infectious diseases. Antibiotics are used in *phytosanitary* treatment, fish farming, and veterinary medicine where antibiotics can also be used as a preventive or curative treatment in livestock management. Several types of antibiotics that are often used include the β-lactam group: penicillin, ampicillin; aminoglycoside group: gentamicin, streptomycin; tetracycline group: tetracycline, oxytetracycline; macrolide group: tylosin, tilmicosin; peptide group: bacitracin, colistin; polyether group: salinomycin, monensin (Widiasih *et al.*, 2020).

The use of antibiotics in livestock can result in residues in livestock products such as meat, milk, and eggs that are consumed by humans. Antibiotics used as therapy for diseases caused by bacterial infections must pay attention to the dosage and stopping time of the drug when the livestock is slaughtered (Masrianto, *et al.* 2019). The use of antibiotics that are not appropriate to the dosage and/or not by the diagnosis of the disease (Yuningsih, 2005), not paying attention to the drug withdrawal period (Donkor *et al.* 2011), or mixing feed additive in raw materials in self-made concoctions on farms where the exact dosage is not guaranteed (Yani, *et al.* 2022) can cause residues in livestock tissues or organs.

We found in this study that 15 authors researched antibiotic residues in broiler meat in the last five years. In general, 13 authors researched to find the level of certain antibiotic residues in broiler chicken meat in Indonesia descriptively and two other authors reviewed the same topic using the narrative review method.

Several research data findings related to antibiotic residue profiles in the last five years in Indonesia are presented in Table 1.

Antibiotic Resistance

Antibiotic resistance is a health problem throughout the world because it can result in the treatment process for bacterial infections being ineffective. Even if efforts are not made to overcome this, antibiotic resistance could become the number one cause of death, beating cancer in the next 50 years. 20% of the source of antimicrobial resistance comes

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from irrational patterns of antibiotic use in humans and 80% is caused by food chain factors of animal origin. Food of animal origin is a medium for the spread of resistant bacteria from animals to humans and the environment, both commensal and pathogenic bacteria (Putri, *et al.* 2018). The use of antibiotics in livestock farming contributes to antimicrobial resistance due to the presence of antibiotic residues in animal-derived products (e.g., muscles, kidney, liver, fat, milk, and egg) (Salam, *et al.* 2023).

E. coli, one of the normal intestinal microflora, is often used as a research object, both as a sign of contamination and to see the ability of antibiotic resistance (Purwanto, *et al.* 2019). The spread of *E. coli* bacteria to humans usually occurs due to the consumption of raw poultry meat. Resistant *E. coli* bacteria will remain in the liver of broiler chickens until harvest time. *E. coli* that is resistant to antibiotics can transfer resistance genes to humans through the food chain or by direct contact. *E. coli* bacteria will enter humans through food. If broiler chicken livers are not cooked at temperatures above 60°C, the bacteria will not die, in the intestines, the process of transferring resistant genes will occur through horizontal transfer which carries resistance traits (Syahputri, *et al.* 2020).

Of the 32 selected articles related to the title of this research, 11 articles discussed the topic of antibiotic resistance in broiler chicken meat in Indonesia. Nine researchers conducted descriptive research and two researchers discussed this topic in narrative review writing. In discussions related to antibiotic resistance, seven articles examine antibiotic resistance for *Escherichia coli* bacteria, one researcher examines antibiotic resistance for *Staphylococcus aureus* bacteria, and one researcher examines antibiotic resistance in bacteria that cause non-typhoidal Salmonella. Several studies on antibiotic resistance originating from broiler chicken meat samples in Indonesia in the last five years are presented in Table 2.

This research found that there was not much research on residues and antibiotic resistance in broiler chicken meat carried out in Indonesia in the last five years. There are a total of 20 articles from descriptive research related to residues and antibiotic resistance in broiler chicken meat in Indonesia during that period. Of the total, 12 articles were researched on antibiotic residues, seven were research articles on the topic of antibiotic resistance, and one article researched both topics at once. This research also took four narrative review articles related to antibiotic residues and resistance, two articles on the topic of food safety, and four articles related to antibiotic use.

Table 1. Profile of antibiotic residues in broiler chicken meat in Indonesia in five years (2018-2023)

Types of products	Area	Year	Sample	Positive (%)	Residue type	Test method	Source
Meat	Parepare	2018	16	0	Oxytetracycline	Bioassays	Rasbawati and Irmayani (2018)
Meat	Yogyakarta	2019	24	8.3 (Oxytetracyclin)	Tetracyclines, Aminoglycosides, Macrolides, Penicillins	Bioassays	Widiasih, *et al.* (2020)
Meat, liver	Pidie Jaya Regency, Aceh	2019	52	0.2 (Penicillin)	Tetracyclines, Aminoglycosides, Macrolides, Penicillins	Bioassays	Masrianto, *et al.* (2019)
Meat	Surabaya (East)	2019	32	96.9	Tetracycline	Spectrophotometric	Aniza, *et al.* (2019)
Meat	Surabaya City	2019	35	17 (Tetracycline) 3 (Penicillin)	Penicillins, Tetracyclines, Macrolides, Aminoglycosides	Bioassays	Wulandari *et al.* (2019)
Meat	Pontianak City	2019	5	60 (Tetracycline)	Tetracyclines, Aminoglycoses, Macrolides, Penicillins.	Bioassays	Tribudi, *et al.* (2020)

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Types of products	Area	Year	Sample	Positive (%)	Residue type	Test method	Source
Meat	Kudus Regency	2019	78	0	Tetracycline	Bioasays	Aulia, *et al.*(2023)
Meat	Banyuwangi	2020	10	0	Tetracycline	Bioassays	Subagyo *et al.* (2021)
Meat	Purwokerto	2020	14	7.14	Tetracycline	Bioassays	Widhi & Saputra (2021)
Meat, liver	Gorontalo	2020	24	0	Tetracyclines, Aminoglycosides, Macrolides, Penicillins	Bioassays	Yani, *et al.* (2022)
Meat	Selemadeg Timur, Tabanan, Bali	2022	10	0	Tetracyclines, Aminoglycosides, Macrolides, Penicillins	Bioassays	Permatasari, *et al.* (2022)
Meat	Pangkajene City, Kab. Pangka	2022	8	0	Kanamycin, Oxytetracycline, Penicillin, Tilosin	Bioassays	Effendi & Masir (2022)
Meat	Semarang	2022	47	9.1	Oxytetracycline	Bioassays, HPLC	Sutiningsih,*et al.* (2023)

Table 2. Profile of antibiotic resistance in broiler chicken meat in Indonesia in five years (2018-2023)

Types of products	Area	Year	Sample positive for contamination	Positive (%)	Resistance type	Test method	Source
Meat	Sumbersari District, Jember Regency	2017	4 (*E. coli*)	50	Tetracycline	*Kirby-Bauer disk diffusion method*	Putri, *et al* (2018)
Meat	Surabaya	2020	4 *(E. coli)* 8 (*Staphylococcus aureus*)	0 25	Cefotaxime Cefoxitin	*Kirby-Bauer diskdiffusion method*	Sudarmadi *et al.* (2020)
Fresh meat	Bogor, South Jakarta, South Tangerang	Nov 2020 - May 2021	20 (*E. coli*)	45 60 20 10 30	Sulfamethoxazole Colistin Ciprofloxacin Chloramphenicol *Multidrug resistance* (2 types ofantibiotics)	*Kirby-Bauer diskdiffusion method*	Naipospos, *et al.* (2021)
Frozen meat	Bogor, South Jakarta, South Tangerang	Nov 2020 - May 2021	22 (*E. coli*)	59 45 18 9 32 5	Colistin Sulfamethoxazole Ciprofloxacin Chloramphenicol *Multidrug resistance* (2 types ofantibiotics) *Multidrug resistance* (3 and 4 types of antibiotics)	*Kirby-Bauer diskdiffusion method*	Naipospos, *et al.* (2021)

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Types of products	Area	Year	Sample positive for contamination	Positive (%)	Resistance type	Test method	Source
Meat	Indonesia	2021	50 (Non-Typoidal Salmonella)	60 54 46	Nalidixic Acid Tetracycline *Multi antimicrobial resistant*	*Mikrodilution method*	Takaichi, *et al.* (2022)
Meat	Mataram City	2022	5 (*E. coli*)	40 20 80	Tetracycline Gentamicin Penicillin G	*Kirby-Bauer diskdiffusion method*	Dita and Kholik (2023)
Meat	East Java	2022	54 (*E. coli*)	66.7 61.1 59.3 35.2 33.3 27.8 24.1 24.1 59.26	Erythromycin Trimethoprim Ampicillin Ciprofloxacin Streptomycin Cephalotin Tetracycline Chloramphenicol *Multidrug resistance*	*Kirby- Bauer disk diffusion method*	Wibawati, *et al.* (2023)

All articles taken in this research come from journals and proceedings, both national and international. In total, there are 23 journals, consisting of 15 national journals and seven international journals, with 18 of them indexed at the international level. Three proceeding articles; two from national conferences and one from an international conference. In addition, there are two references from books, a report, and three protocols.

Table 1 shows the data collected in this research regarding the findings of antibiotic residues in chicken meat in Indonesia. Based on the data, it appears that the incidence of antibiotic residue in broiler meat still occurs with low to quite high intensity, especially for tetracycline antibiotics 8,3%-96,9% found from seven research articles (53.85% of cases).

Penicillin residues were also found in this study, namely in two research articles (15.38% of cases) with low percentages of 0.2% and 3%. In addition, 46.15% of cases or six research articles did not find antibiotic residues in broiler chicken meat. The classes of antibiotics whose residue content was examined by the researchers in their research were the four main classes of antibiotics; tetracycline, aminoglycoside, penicillin, and macrolides. Most researchers studied all four classes of antibiotics at the same time, namely by seven researchers. Meanwhile, six other studies only examined residues from the tetracycline group.

Tetracyclines are antibiotics commonly used in animal husbandry, including broiler farming (Widhi and Saputra, 2021). On the market, there are various brands of tetracycline drugs available in the form of powder, caplets, and injections which are easily obtained by farmers. This finding may indicate that supervision of the use of antibiotics in the management of broiler farming is still weak. Even though broiler chicken feed no longer contains antibiotics as feed additives, the use of antibiotics separately for therapeutic or preventive purposes may still be practiced by farmers without being accompanied by correct use management and good supervision. This finding may indicate that the antibiotic dose size may not be appropriate, or the duration of use is long, and the withdrawal time is not implemented, so the antibiotic has not been completely metabolized.

The bioassay method is used by almost all researchers, one of which also uses the HPLC (High-Performance Liquid Chromatography) assay method, and only one researcher used spectrophotometric methods. A bioassay test is a qualitative test for detecting any antibiotic residue at one time. The HPLC and spectrophotometry test is a specific quantitative test to measure the level of residue content of one particular type of antibiotic.

Table 2 presents data on findings of antibiotic resistance in broiler chicken meat in Indonesia in

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the period 2018 to 2023. Researchers generally detected resistance in the *E. coli* bacteria found to contaminate broiler meat in their research samples, namely by six researchers out of a total of seven studies. Apart from that, there are also *Staphylococcus aureus* bacteria and non-typhoidal Salmonella. These bacteria are commonly found contaminating meat. *E. coli* is a bio-indicator for water sanitation and contamination. *E. coli* is also a bacterium commonly used in surveillance and monitoring programs as an indicator that can provide information about the transmission of the potential reservoir of antibiotic-resistant genes to pathogenic bacteria (Naipospos *et al.*, 2021). Five researchers conducted resistance research for several types of antibiotics, two researchers only studied one type of antibiotic for each bacteria.

As a testing method, six researchers used the Kirby-Bauer disk diffusion method and one researcher used the microdilution method. Both of these test methods are phenotypic antimicrobial susceptibility tests. Phenotypic antibiotic susceptibility testing (AST) is a method for determining the effectiveness of antibiotics against bacterial infections. This involves testing the ability of bacteria to grow in the presence of various antibiotics to determine susceptibility or resistance to those antibiotics. This is usually done by measuring the size of the zone of inhibition that forms around the paper disc containing the antibiotic on the agar plate. The size of the inhibitory zone corresponds to the antibiotic concentration and can be used to determine the minimum inhibitory concentration (MIC), which is the lowest antibiotic concentration capable of inhibiting bacterial growth. Phenotypic AST methods include disc diffusion, dilution, and Etest. This method provides qualitative and quantitative information about the susceptibility of bacteria to antibiotics and helps choose appropriate antibiotic therapy for each patient.

The incidence of antibiotic resistance in microorganisms found in broiler meat based on search results of existing research articles is quite disturbing because resistance isfound in almost all classes of antibiotics, with quite high percentages, as well as the existence of multidrug resistance. It was found that the greatest resistance, 50%-80%, was found in first-line β-lactam antibiotics (penicillin, ampicillin). Antibiotics from the same group in the second line have also experienced resistance of 25%-28% (cefalotin, cefoxitin). Resistance is also quite high in several other classes of antibiotics; macrolides (erythromycin), polymyxins (colistin), and first-generation quinolones (nalidixic acid) in the range of 60%. The sulfonamide group experienced resistance in 50-60% (sulfamethoxazole, trimethoprim), second-generation quinolones (ciprofloxacin) in the range of 18-35%, tetracyclines in the range of 20-50%, and

aminoglycosides in the range of 20-30% (gentamicin, streptomycin). In broiler chicken meat, resistance to chloramphenicol was also found in the rangeof 9-25%. Antibiotics that have experienced resistance are included in the list of critically important and highly important antimicrobial agents for humans. Ciprofloxacin, erythromycin, and colistin are included in the Highest Priority Critically Important Antimicrobial Agents. Meanwhile, penicillin, ampicillin, sulfamethoxazole-trimethoprim, gentamycin, and streptomycin are included in the High Priority Critically Important Antimicrobial Agent category. Tetracycline, cefalotin, cefoxitin, and chloramphenicol are included in the Highly Important Antimicrobial Agent category. Researchers also found multidrug resistance in their research with varying ranges; in general, it was in the range of 46% to 59%, 30% for resistance to two types of antibiotics at once, and 5% for resistance to three to four types of antibiotics at once.

Colistin and chloramphenicol were also found to be resistant to chicken meat, the use of which has been banned by the Indonesian government. Colistin has been banned for use in animals since 2019 and the use of chloramphenicol in livestock since 2017. These findings indicate two possibilities, that these two drugs are still widely circulating on the Indonesian market for animal use, and/or that bacteria are resistant in humans or the environment which then contaminate chicken meat.

This fact illustrates the failure to use antibiotics wisely in the field, both in livestock management itself, the misuse of antibiotics by humans, as well as environmental pollutionby resistant bacteria and poor sanitation hygiene practices. Microorganisms in broiler meat resistant to antibiotics and multidrug resistance can transfer their resistance genes to other microorganisms and cause wider antibiotic resistance in the environment and humans who consume them. This condition is alarming and requires joint attention.

Seeing this condition, continuous guidance and supervision are needed in the production chain of animal-origin foodstuffs so that dangers can be minimized. In the world of animal husbandry, the responsible use of antimicrobials in livestock management is a fundamental thing that is important to pay attention to. The use of antibiotics on farms should be under the supervision of a veterinarian. Supervision of the distribution of antibiotics on the market also needs to be tightened, one of which is by emphasizing the importance of a veterinarian's prescription in every transaction. It is also important to implement correct hygiene and sanitation practices throughout the broiler meat production and distribution chain to limit contamination at every stage. Every animal-origin food product business needs to receive guidance and be

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encouraged to obtain NKV certification (Veterinary Control Number) to guarantee food safety. Education and assistance need to be provided continuously to all actorsin the broiler chicken meat production and distribution chain to increase understanding and raise collective awareness. Education for consumers also needs to be promoted regarding the correct handling and processing of broiler chicken meat by paying attention to storage and processing temperatures, to minimize antibiotic residues in broiler chicken meat, and to kill pathogenic germs that contaminate the meat, including germs that are resistant to antibiotic.

CONCLUSION

Residues and antibiotic resistance are two indicators of food safety from livestock that are important to monitor regularly to increase awareness of the dangers they can cause, as well as the steps that need to be taken to control them. Antibiotic residues are found in broiler chicken meat in Indonesia, especially from the tetracycline group. This indicates that there are still irregularities in the management of antibiotic use in the broiler chicken farming industry. Antibiotic resistance in microbes in chicken meat in Indonesia is found in low to high concentrations in almost all classes of antibiotics. This finding is related to the inappropriate use of antibiotics and the implementation of poor hygiene and sanitation practices in the broiler chicken meat production and distribution chain. This condition needs serious attention because it has the potential to threaten environmental and human health. Proper processing of meat is important to minimize the risks that can occur. Continuous guidance and supervision of the broiler chicken meat production and distribution chain is very important.

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