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Nutritional attributes and antibiotic residue burden in broiler chicken meat: A critical review

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Abstract
Broiler chicken meat is one of the most popular sources of animal protein in the world. This is because it is cheap, has a lot of nutrients, and has less fat than red meat. It is a great source of vitamins, minerals, and amino acids that are good for your health. But the growth of poultry production systems has made it common to use antibiotics for therapeutic, preventative, and growth-promoting reasons. This has caused a lot of worry about the presence of antibiotic residues in poultry meat and what they could do to people's health. The presence of these residues in edible tissues leads to the emergence of antimicrobial resistance, hypersensitivity reactions, and the disruption of normal gut microbiota. This review provides a thorough examination of broiler chicken meat's nutritional profile, the determinants of its quality, the use of antibiotics in poultry farming, and the presence and identification of antibiotic residues. Furthermore, the review considers public health implications, current regulatory frameworks, and novel approaches to mitigating environmental pollution stemming from antibiotic residues. The conclusions emphasize the significance of sustainable poultry practices and the necessity for more stringent regulations to safeguard consumer well-being and uphold food safety standards.

Keywords: Broiler chicken, nutritional quality, antibiotic residues, poultry farming, antimicrobial resistance, food safety

Introduction

Poultry meat, especially broiler chicken, is now a big part of the diets of people in both developed and developing countries. The increasing demand for poultry is largely due to rapid urbanization, population growth, and changing dietary preferences that favor high-protein, low-fat foods (Kleyn & Ciacciariello, 2021) [11]. Poultry farming is a good way to get animal protein because it has shorter production cycles, better feed conversion rates, and lower costs compared to other types of livestock farming.

Broiler chicken meat is highly valued nutritionally because it has a good balance of amino acids, low levels of collagen, and is easy to digest. It is also a good source of micronutrients like niacin, vitamin B6, phosphorus, and selenium, which are important for metabolism and the immune system. The nutritional attributes of chicken meat render it a crucial resource in combating protein-energy malnutrition across numerous global regions (Kralic *et al*., 2018).

Despite these benefits, the expansion of poultry farming has presented several challenges, particularly concerning food safety. The use of antibiotics in this sector is a significant concern (Haque *et al*., 2020) [7]. These drugs are widely used in poultry farming to treat infections, prevent disease, and promote faster growth. However, improper use, particularly not following the required withdrawal periods, has led to the accumulation of antibiotic residues in poultry. The presence of these residues in food can significantly harm human health, particularly by contributing to antimicrobial resistance (AMR), which is considered a major health threat in the 21st century (Salam *et al*., 2023) [17]

Hence, in order to maintain the food safety and protect public health, it is mandatory to know how to balance the health benefits of broiler chicken with the risks of antibiotic residues.

The nutritional profile of broiler chicken meat is widely recognized, rendering it a significant component of a balanced diet.

Protein constitutes the principal component of chicken meat, accounting for approximately 18% to 23% of its overall composition; this percentage is subject to variation based on the chicken's breed, age, and feeding practices (Hailemariam *et al*., 2022) [6]. This protein is regarded as high-quality, as it contains all essential amino acids necessary for human development and health. Furthermore, chicken meat is especially abundant in amino acids, including lysine and methionine, which are often present in lower concentrations in plant-based food sources.

Furthermore, the lipid profile of broiler chicken meat significantly contributes to its nutritional value, in addition to its protein content. Chicken meat typically exhibits a lower concentration of saturated fat and a higher proportion of unsaturated fatty acids, including linoleic acid, when compared to red meat (Milićević *et al*., 2014) [14]. When eaten as part of a balanced diet, this good lipid profile is linked to a lower risk of heart disease.

Chicken is also a great source of vitamins, especially B-complex vitamins. Vitamin B3, also known as niacin, is very important for energy metabolism. Vitamin B6 is important for amino acid metabolism and the making of neurotransmitters. Vitamin B12 is important for making red blood cells and keeping the nervous system working, even though it is only present in small amounts.

Table 1: Nutritional Composition of Broiler Chicken Meat (per 100 g)

Component	Approximate Value
Protein	18–23 g
Fat	5–15 g
Energy	165–239 kcal
Iron	1.0–1.3 mg
Zinc	1–2 mg
Vitamin B6	0.5 mg
Vitamin B12	0.3 µg

There are a lot of minerals in it, like phosphorus, selenium, and zinc. Selenium is a strong antioxidant that helps the immune system. Iron is still present in bioavailable forms, which helps prevent anemia, even though it is lower than in red meat.

Nutritional quality hampering factors

The nutritional makeup of broiler chicken meat is not fixed; it can be changed by many biological and environmental factors. Feed composition is one of the most important factors. Adding high-quality protein sources to your diet can help your muscles grow, and adding omega-3 fatty acids to your diet can make the meat's lipid profile better. The conditions in which animals are raised also have a big impact on the quality of the meat (Idowu *et al*., 2026) [9].

Birds that are kept in stressful environments, like being too crowded or poorly ventilated, may have a different metabolism, which can make their meat less tasty (Franco *et al*. 2017) [5]. Stress before slaughter is especially bad because it can lead to problems like pale, soft, exudative (PSE) meat. The way food is handled and stored after it is killed also affects how long nutrients stay in it. If you do not store meat properly or keep it for too long, the lipids can break down, and the vitamins can be lost. This makes the meat less healthy and safe to eat.

Use of antibiotics in chicken farming

For decades, antibiotics have been an important part of modern poultry farming. They are used to treat bacterial infections, to stop disease outbreaks, and in some places, to help animals grow by making their feed more effective and helping them gain weight. Tetracyclines, fluoroquinolones, sulfonamides, and macrolides are all types of antibiotics that are often used on poultry (Agyare *et al*., 2018) [2]. While their use has certainly boosted productivity, it has also had unintended effects, especially when used carelessly.

Table 2: Common Antibiotics Used in Poultry and Their Residue Limits (MRLs)
(Compiled from Codex Alimentarius, WHO, FSSAI-aligned standards — widely accepted ranges)

Antibiotic Class	Example Drug	Target Pathogens	MRL in Muscle (µg/kg)
Tetracyclines	Oxytetracycline	Broad-spectrum bacteria	100
Fluoroquinolones	Enrofloxacin	Gram-negative bacteria	100
Sulfonamides	Sulfamethazine	Coccidia, bacteria	100
Macrolides	Erythromycin	Respiratory pathogens	200
Aminoglycosides	Gentamicin	Severe infections	50

One of the biggest problems with using antibiotics is that people do not always follow the right withdrawal periods, which is the time it takes for the drug to leave the animal's body before it is killed. If you do not follow these rules, antibiotic residues will stay in edible tissues like muscle, liver, and kidney.

Antibiotic Residues in Chicken Meat

Many studies from different parts of the world have found antibiotic residues in broiler chicken meat. The scope of this issue extends beyond a single domain (Mund *et al*., 2017 and Muhammad *et al*., 2020) [15, 16]. These residues have the strong ability to infiltrate the food chain, thereby exerting selective pressure on microbial populations, which may subsequently foster the emergence of resistant strains. Novel analytical techniques have significantly improved the detection of antibiotic residues.

Although traditional microbiological assays are inexpensive, they have limitations in terms of specificity and sensitivity (Hossain, 2024) [8]. In contrast, chromatographic methods, such as High-Performance Liquid Chromatography (HPLC) and Gas Chromatography (GC), offer greater accuracy and reliability (Siddiqui, 2021).

Table 3: Detection Methods for Antibiotic Residues

Method	Advantages	Limitations
Microbiological assay	Simple, cost-effective	Low specificity
HPLC	Accurate, reliable	Expensive
GC	High sensitivity	Requires derivatization
LC-MS/MS	Highly sensitive, precise	High cost
ELISA	Rapid screening	Less confirmatory

Chromatography coupled with Mass Spectrometry (LC-MS/MS) have become the best way to find residues because they are very sensitive and can find more than one residue at a time. Immunological techniques, including Enzyme-Linked Immunosorbent Assay (ELISA), are extensively employed for expedited screening.

Effects on Public Health

Antibiotic residues in broiler chicken meat are very bad for human health. One of the most important issues is the rise of antimicrobial resistance (Arsène *et al*., 2022) [3]. Regularly consuming food with low levels of antibiotics can lead to the growth of bacteria that are resistant to those antibiotics (Serwecińska, 2020) [18]. These bacteria can then pass on their resistance genes to harmful microorganisms.

Table 4: Health Risks Associated with Antibiotic Residues

Health Impact	Mechanism	Evidence Level
Antimicrobial resistance	Selection pressure on bacteria	Strong
Allergic reactions	Drug hypersensitivity	Moderate
Gut microbiota disruption	Alteration of microbial balance	Emerging
Toxicity (long-term)	Bioaccumulation	Limited

Aside from AMR, antibiotic residues can also make people who are sensitive to them allergic. Penicillin and some other antibiotics are known to cause hypersensitivity reactions even when they are in low amounts (Legendre *et al*., 2014) [13]. Another growing worry is how antibiotic residues affect microbiota in the human gut. Disturbance of the natural microbial equilibrium can result in gastrointestinal disorders and may impair immune function. Long-term exposure to antibiotic residues has been linked to possible toxic effects, but more research is needed to fully understand what this means.

Regulatory Frameworks and Control Measures

To overcome the risk factors of antibiotic residues, many national and international regulatory bodies have established guidelines and standards for increasing food safety. Maximum Residue Limits (MRLs) are the legally allowed highest amounts of residue in food products (Khandelwal *et al*., 2022) [10]. The World Health Organization, the Food and Agriculture Organization, and the Codex Alimentarius Commission are all significant actors in the realm of global standards (Fortin, 2023) [4]. Within India, the Food Safety and Standards Authority is the body tasked with overseeing food safety. This encompasses monitoring antibiotic residues present in animal-derived products.

Table 5: Comparison of Antibiotic-Based vs Antibiotic-Free Poultry Production

Parameter	Antibiotic-Based System	Antibiotic-Free System
Growth rate	Faster	Moderate
Disease risk	Lower (controlled)	Higher (if unmanaged)
Residue risk	High	Negligible
Consumer acceptance	Moderate	Very high
Market value	Standard	Premium

Implementing these guidelines, however, remains a challenge. This is especially true in developing areas, where monitoring systems are weak or they can be.

Minimizing Antibiotic Residues among the chicken meat

Several strategies exist for minimizing antibiotic levels in poultry. Adhering to withdrawal periods is crucial for preventing residues from remaining in meat. Furthermore, better farm hygiene and biosecurity practices can reduce the need for antibiotics by lessening the occurrence of disease outbreaks. Probiotics, prebiotics, and photobiotic are alternative strategies that have shown promise in improving gut health and boosting immunity in poultry, without using antibiotics (Acharya & Barsila, 2025) [1]. Additionally, vaccination programs are very important for stopping the spread of diseases. Moreover, increasing public awareness of this issue, along with encouraging responsible antibiotic use, are important steps toward making poultry production more sustainable.

Future Considerations

The trajectory of poultry production necessitates the development of systems that prioritize animal welfare, environmental stewardship, and food safety, while simultaneously eliminating antibiotic usage. Significant advancements in biotechnology, including the application of nanotechnology for residue detection and the implementation of precision farming techniques, are poised to play a crucial role in this transformation. To reduce the problems caused by antibiotic residues, it is crucial to improve monitoring systems. This will help regulatory agencies, researchers, and industry professionals work together more effectively.

Conclusions

Globally, broiler chicken meat remains a crucial source of high-quality nutrition. However, increasing public concern regarding antibiotic residues necessitates a careful equilibrium between safety and productivity. Safeguarding public health requires the judicious application of antibiotics, the enforcement of stringent regulations, and the continuous development of novel alternatives. Therefore, the combined efforts of all involved, along with specific actions, are crucial for promoting sustainable poultry farming and ensuring consumers have access to safe and healthy food.

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