

Rezistența la antibiotice: o provocare pentru industria de prelucrare a cărnii – un rezumat

Antibiotic resistance: a challenge for the meat processing industry – a review

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Rezumat

Rezistența la antibiotice (ABR) are repercusiuni directe și indirecte asupra sănătății publice și amenință să reducă efectul terapeutic al tratamentelor cu antibiotice și să ducă la mai multe decese cauzate de infecții. Există mai multe mecanisme prin care ABR poate fi transferată de la un microorganism la altul. Riscul de transfer este adesea legat de factori de mediu. Lanțul de aprovizionare cu alimente oferă condiții în care transferul genelor de rezistență la antibiotice poate avea loc prin multiple căi, generând îngrijorări cu privire la siguranța alimentară.

Abstract

Antibiotic resistance (ABR) has direct and indirect repercussions on public health and threatens to decrease the therapeutic effect of antibiotic treatments and lead to more infection-related deaths. There are several mechanisms by which ABR can be transferred from one microorganism to another. The risk of transfer is often related to environmental factors. The food supply chain offers conditions where antibiotic resistance gene transfer can occur by multiple pathways, which generates concerns regarding food safety.

Introduction

Antibiotics are drugs used to prevent and treat bacterial infections. However, antibiotic resistance occurs when bacteria adapt in response to exposure to antibiotics, allowing them to survive treatments that were previously effective. This adaptation makes infections harder to treat, increasing the risk of disease spread, severe illness, and even death [25,27,32].

Bacterial resistance specifically refers to a bacterium's ability to withstand the effects of an antibiotic, meaning it can survive or grow despite the presence of the drug at therapeutic levels [1,12].

Antibiotic resistance has escalated into a critical global issue, where antibiotics no

longer reliably treat the infections for which they were designed [36].

The World Health Organization (WHO) has emphasized that the world is "running out of antibiotics", highlighting the alarming rate of antibiotic resistance globally.

Recently, the emergence of drug-resistant bacteria has become a significant barrier to treating clinical infectious diseases, with a concurrent rise in hospital-acquired infections [9,37].

Bacterial resistance is increasing worldwide, affecting healthcare systems as new resistance mechanisms continue to emerge and spread internationally. The global spread of antibiotic resistance limits treatment options for common infectious diseases,

representing an urgent public health concern [11,24,31,37].

As antibiotics lose their effectiveness, treating infections such as pneumonia, tuberculosis, sepsis, gonorrhea, and foodborne illnesses is becoming increasingly challenging, if not impossible [8].

Decades after the introduction of antibiotic treatments, bacterial infections once again pose a severe threat.

Without immediate and decisive action, we are on the verge of entering a post-antibiotic era, where even common infections and minor wounds could become fatal [4,10].

Antibiotic Resistance

Antibiotics are natural, synthetic, or semi-synthetic substances that can inhibit the growth of microorganisms responsible for human and animal diseases [15, 33].

Antibiotic resistance, a natural process, occurs when antibiotics that were previously effective against specific bacterial infections lose their ability to control or kill these pathogens [7, 20, 34].

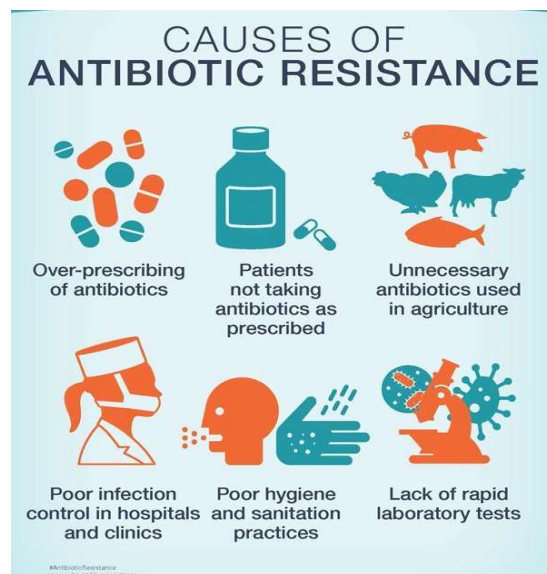


Figure 1. Causes of antibiotic resistance (Source: Centers for Disease Control and Prevention, <https://healthjournalism.org/blog/2019/08/how-a-journalist-overcame-challenges-of-covering-antibiotic-resistance/>)

Exposure to antimicrobial agents eliminates sensitive bacteria but allows the survival and development of resistant strains, either naturally resistant or those that have acquired resistance traits due to selective pressure [7].

Although overuse of antibiotics is a key factor in the development of resistance, other factors such as incorrect use, wrong dosage, and non-compliance with treatment guidelines also contribute to the spread of resistance [15,21,23].

Mechanisms of antibiotic resistance

It is essential to clarify the concepts of persistence and resistance. Both involve a small subset of bacterial cells that survive antimicrobial treatments.

However, resistance occurs when the offspring of a bacterium inherit traits that allow them to survive antibiotics. In contrast, persistence refers to bacterial cells that can temporarily survive the antimicrobial agent but do not have inheritable resistance genes for future generations [16].

Persistence is often due to certain cells in the population entering a stationary growth phase, during which they are less affected by antimicrobials that target actively dividing cells [17].

Unlike antibiotic-resistant (ABR) cells, persistent cells can become susceptible to the antibiotic when they resume active growth and begin a new population.

Bacteria use four main mechanisms for antibiotic resistance:

1. reducing drug absorption,
2. modifying the drug target,
3. inactivating the drug, and
4. actively pumping the drug out of the cell [2].

These mechanisms can be part of innate (natural) or acquired resistance and may vary depending on the bacterial cell structure.

Limiting drug absorption, inactivating the drug, and pumping the drug out are natural resistance mechanisms, while modifying the drug target, inactivating the drug, and pumping the drug out are often acquired adaptations [8].

Antibiotic Resistance: Implications for Public Health

Food safety is essential in the food supply chain as it defines the quality of the final product and directly affects consumer confidence. The introduction of the Hazard Analysis and Critical Control Points (HACCP) system has transformed the food industry, providing a structured approach to managing food safety at all stages of processing.

This system, known as the "Food Safety Management Program", integrates preventive measures to control risks and prioritize consumer protection [16,19].

Many companies now follow this program to ensure food safety, addressing risks that could compromise product integrity.

Among the most common risks are accidental microbial or chemical contamination, but these programs often overlook intentional adulteration, which can be more difficult to detect [6,13].

Food fraud, also known as economically motivated adulteration (EMA), involves actions such as deliberate alteration, substitution, dilution, or falsification of a product or its ingredients for financial gain.

Although EMA has historical roots, these illicit practices have expanded with globalization and international food trade.

Due to the complex food industry, tracking product integrity throughout the supply chain is difficult, and adulteration can occur during transportation.

Food fraud not only compromises product safety but also has economic impacts, as seen in cases such as the melamine contamination of dairy products in

China in 2008 and fipronil-contaminated eggs in 2017.

It can also expose consumers to unauthorized additives, such as antibiotic residues, an increasing concern regarding food safety [14].

For example, antibiotic residues have been detected in various foods, predominantly from animal sources, but also in processed products available on the market [18].

In 2009, shipments of honey containing antibiotics were mislabeled and sold in the United States, despite non-compliance with regulations [29].

Antibiotic residues are more common in food from developing countries, where regulatory oversight and educational standards may be less rigorous. Standardizing antibiotic regulations for agriculture is challenging due to regional differences in practices [3].

However, international agencies such as the World Health Organization (WHO) and the European Food Safety Authority (EFSA) have worked to establish country-specific guidelines for better regulation [2].

These standards include acceptable daily intake (ADI), withdrawal time (WT) to allow for the removal of antibiotics from animal-derived products, and maximum residue levels (MRLs) [22].

Despite international efforts to enforce MRLs through the World Trade Organization and Codex Alimentarius, monitoring antibiotic residues remains a challenge because MRLs vary regionally [2,22].

Deficiencies in regulation and improper antibiotic use, both in human and animal contexts, have allowed antimicrobial resistance (AMR) to emerge as a major public health risk [34].

AMR represents a serious threat not only to food safety but also to global health [26].

Since 2015, AMR has been a priority, with the WHO's "Global Action Plan on

Antimicrobial Resistance" promoting the responsible use of antibiotics and strategies to reduce reliance on antibiotics.

The plan has identified growing risks, such as common bacterial infections such as tuberculosis, sexually transmitted infections, urinary tract infections, pneumonia, and foodborne diseases becoming harder to treat due to widespread resistance to conventional antibiotics [28].

This resistance has led to the emergence of multidrug-resistant (MDR) bacteria, which can resist multiple antibiotics. MDR organisms pose a serious threat to public health, with infections caused by pathogens such as:

- *Acinetobacter baumannii*,
- *Escherichia coli*,
- *Pseudomonas aeruginosa*,
- *Klebsiella pneumoniae*,
- *Staphylococcus aureus*,
- *Streptococcus pneumoniae*,
- *Enterococcus faecium*, and
- *Enterococcus faecalis*

showing higher mortality rates. Irresponsible antibiotic use affects both public health and economic stability by increasing the costs and complexity of treatments [17,30,35].

Few countries have antibiotic use surveillance systems, highlighting the need for comprehensive local and global regulations that establish safe and effective practices for antibiotics in the food industry [17].

Although advances in microbial detection have improved food safety, most current practices still rely on testing final products for risks at the end of processing.

This approach, while valuable for certain purposes such as batch verification, does not cover all contamination risks, especially with antibiotic residues [38].

Common detection techniques include high-performance liquid chromatography (HPLC) and mass spectrometry (MS), which

provide precise quantifications of antibiotic residues at low levels.

However, these methods typically only test final products, and residues are not tracked through the processing stages, which is critical given the public health risks associated with antibiotic residues in food [8].

The presence of antibiotic residues affects animal health, the environment, food production, and consumer safety [2].

Antibiotics can accumulate in crops, drinking water, and animal products, either as original substances or by-products.

A study in China found 58 types of antibiotics in water and 49 in food, estimating a daily intake of 310, 200, and 130 ng/kg body weight for children, adolescents, and adults [4].

Antibiotic residues can cause direct health problems such as allergic reactions and toxicity, as well as contribute to antibiotic resistance [5].

They can cause allergic reactions with symptoms such as rashes, serum sickness, thrombocytopenia, hemolytic anemia, and severe conditions like Stevens-Johnson syndrome [28].

There are also potential links between these residues and other health risks, including hepatotoxicity, carcinogenesis, and reproductive issues.

Conclusions

Antibiotic resistance has become a significant global health threat as bacteria adapt and survive treatments that once eliminated them, leading to the spread of diseases, their worsening, and an increase in mortality.

The World Health Organization (WHO) warns that the world is "running out of antibiotics", highlighting the growing issue of bacterial resistance, which now complicates treatments for infectious diseases.

Excessive and incorrect use of antibiotics, along with incorrect dosing and failure to follow treatment guidelines, are key factors in the development of resistance, making infections that were once treatable increasingly difficult to manage.

Bacterial resistance occurs through four main mechanisms: reduced drug absorption, modification of drug targets, drug inactivation, and active drug expulsion, making infections such as pneumonia, tuberculosis, and sepsis harder to treat.

Antibiotic resistance affects not only human health but also food safety, as antibiotic residues in animal-derived products contribute to the spread of resistance and pose public health risks.

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