Vol. 18(1); May - June 2024

Antibiotic resistance dynamics of the most frequently isolated potentially pathogenic bacteria from the food sector

Dinamica antibiorezistenței celor mai frecvent izolate bacterii cu potențial patogen din sectorul alimentar

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Keywords: *antibiotic resistance, antibacterial substances, public health, pathogenic bacteria, bacterial isolates*
Cuvinte cheie: *antibiorezistenţă, substanţe antibacteriene, sănătate publică, bacterii patogene, izolate bacteriene*

Abstract

Antibiotic resistance is a significant threat to human health, and the food sector often serves as an important reservoir of potentially pathogenic bacteria. In this context, it is important to investigate and know the dynamics of antibiotic resistance at the level of the most frequently isolated bacteria from the food sector. The aim of this study was to highlight the implication of antibiotic resistance in the food sector to protect public health and to counter the emerging threats generated by bioresistance in the food sector. Thus, we presented the role of the food sector in the spread of bioresistance, the methodology necessary to investigate antibiotic resistance in the food sector and the importance of identifying antibiotic resistance in bacteria isolated from food.

Rezumat

Antibiorezistența reprezintă o amenințare semnificativă la adresa sănătății umane, iar sectorul alimentar servește adesea ca un important rezervor de bacterii cu potențial patogen. În acest context, este importantă investigarea şi cunoaşterea dinamicii antibiorezistenței la nivelul celor mai frecvente izolate bacterii din sectorul alimentar. Scopul acestui studiu a fost de a evidenţia implicarea antibiorezistenţei în sectorul alimentar pentru a proteja sănătatea publică şi pentru a contracara ameninţările emergente generate de biorezistență în sectorul alimentar. Astfel, am prezentat rolul sectorului alimentar în răspândirea biorezistenţei, metolodogia necesară investigării antibioriezisteţei în sectorul alimentar şi importanţa indentificării rezistenței la antibiotice în bacteriile izolate din alimente.

Introduction

Antimicrobial resistance, defined as the ability of bacteria to survive exposure to drugs, poses a major challenge to human health and the effectiveness of medical treatments.

The food sector, due to its complex and diverse nature, can serve as an important reservoir for potentially pathogenic bacteria and, consequently, for the development and spread of antibiotic resistance (2, 7).

This paper presents the dynamics of antimicrobial resistance in the case of the most commonly isolated bacteria from the food sector (Figure 1).

The main objective is to highlight the sensitivity of these bacteria to various antibiotics and identify potential resistance mechanisms.

By understanding these aspects, we aim to contribute to the development of effective strategies for managing antimicrobial resistance in the food industry.

Through the collection and analysis of samples from various food sources, we aim to provide a detailed perspective on the current status of antibiotic resistance in this critical domain.

Identifying and presenting these issues could serve as a basis for implementing more responsible agricultural and food practices, thereby reducing the risk of antimicrobial resistance spread and protecting public health (10, 13).

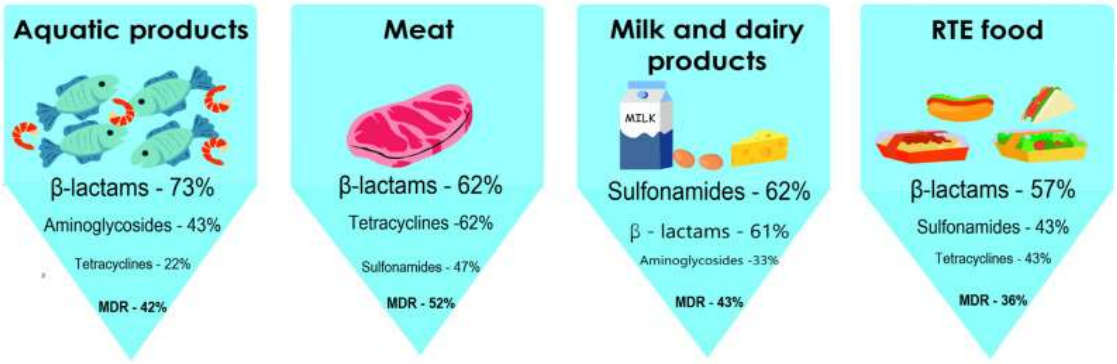

Figure 1. The most common types of antibiotic resistance by type of food product (**Source:** Grudlewska-Buda, K. şi col., 2023)

This work is based on the belief that understanding the mechanisms and patterns of antibiotic resistance in foodborne bacteria is essential for implementing effective management measures.

By analyzing antibiotic sensitivity profiles, we will be able to identify antibiotics that are still effective and, at the same time, highlight areas where resistance is growing (9, 1,15).

This information is crucial for adapting and optimizing treatment regimens.

Additionally, the significant variability among different food sources draws attention to possible influences of environmental, technological, or geographical factors on the development of antibiotic resistance (11,16,18,28).

Another key aspect of this work is highlighting the importance of responsible agricultural practices.

The excessive and inappropriate use of antibiotics in agriculture can significantly contribute to the growth of antibiotic-resistant foodborne bacteria.

By identifying the links between agricultural practices and resistance levels, we can develop guidelines and regulations to promote a balance between agricultural needs and the need to protect human health.

Promoting responsible antibiotic use and implementing sustainable practices in the food sector are essential to ensure that this global public health issue is addressed effectively and sustainably (17,24,26).

In the context of an increasing threat to the effectiveness of medical treatments, understanding the dynamics of antibiotic resistance in the food sector is essential, providing valuable information for the development of effective intervention and control strategies.

Antibiotic resistance and its implications for human health

Antibiotic resistance, as a biological phenomenon, has evolved in recent decades as a complex and pressing issue in human health.

The concept of antibiotic resistance refers to the ability of microorganisms to resist the action of medicinal substances, especially antibiotics, which generates significant difficulties in the treatment of infections (2,3).

The implications of antibiotic resistance for human health are multiple and deeply concerning.

First, the ability of bacteria to evolve and develop resistance to antibiotics reduces the effectiveness of medical treatments, exposing patients to increased risks of complications and even death.

Additionally, antibiotic resistance has a negative impact on the duration and costs associated with medical care.

The spread of antibiotic resistance in the medical community underscores the need for a global and coordinated approach to manage this problem and ensure the availability of effective therapy against bacterial infections (4,5,8).

Furthermore, antibiotic resistance has direct implications for global public health.

The phenomenon is susceptible to facilitating the spread of resistant infections worldwide, due to increased population mobility and international contacts.

This perspective underscores the need for consolidated international cooperation to develop effective strategies for controlling and preventing antibiotic resistance (1,10,14).

The role of the food sector in the spread of antibiotic resistance

The food sector plays a significant role in the spread of antibiotic resistance, providing a conducive environment for the development and transmission of antibiotic resistance genes in different environments and organisms.

This complex phenomenon involves multiple interactions between microorganisms present in food, the surrounding environment, and agricultural and food practices (22,26).

The most important aspects influencing the spread of antibiotic resistance in the food sector are:

- **Excessive use of antibiotics in agriculture:** antibiotics are often used in agricultural practices to promote animal growth and prevent infections. This extensive use can create a conducive environment for the development and selection of antibiotic-resistant bacteria.

- **Transfer of resistance genes through the food chain:** antibiotic-resistant bacteria and resistance genes can be transferred from antibiotic-treated animals to humans through the consumption of contaminated food products. This phenomenon contributes to the increased incidence of antibiotic resistance at the human level.

- **Environmental surroundings and food contamination:** the environment in which animals are raised and food production processes can facilitate contamination with resistant bacteria. This may include contamination of irrigation water, soil, and other natural resources used in food production.

- **International trade of food products:** In the context of globalization, food products can travel between countries and continents. This trade exchange can contribute to the spread of antibiotic-resistant bacteria and associated genes globally.

- **Inadequate food hygiene practices:** Inadequate hygiene practices in food processing and handling can facilitate contamination with resistant bacteria. This may include failure to comply with hygiene standards on farms, slaughterhouses, or in the food production process.

The food sector is an environment where antibiotic resistance can thrive and spread.

Addressing this issue requires special attention to agricultural and food practices, promoting responsible antibiotic use, improving food hygiene, and developing control strategies globally (12, 23).

Methodology for investigating antibiotic resistance

Investigating the dynamics of antibiotic resistance in the food sector requires a rigorous

methodology for collecting samples and evaluating the sensitivity of identified bacteria.

Selection of food sources: identification and selection of food sources are based on their relevance in terms of the potential transmission of pathogenic bacteria to consumers.

This includes animal and plant products, processed and raw products, covering a wide range of commonly consumed foods.

Sampling process: sampling is carried out randomly at different geographical locations and food production units to ensure adequate representativeness.

Samples must be collected by specialized personnel using laboratory-approved techniques.

Each sample must be properly identified and recorded according to the type of food and the place of collection. Sample collection is done with sterile instruments to minimize the risk of contamination.

For packaged foods, the integrity of the packaging is ensured to avoid subsequent contamination.

For raw food products, sampling is done at multiple points to cover the bacterial diversity in different regions of the product.

Transport and storage of samples: after collection, samples must be transported to the laboratory under controlled temperature conditions to maintain the bacteriological integrity.

Upon arrival, they are stored according to laboratory standards to avoid contamination and degradation of biological material.

Identification and documentation of samples: in the laboratory, each sample must undergo a rigorous process of identification and documentation.

Relevant data, such as the type of food, date, and place of collection, are recorded to ensure precise and correlated tracking of results with specific sources.

Analysis of antibiotic sensitivity profiles

Analysis of antibiotic sensitivity profiles is carried out to obtain a detailed understanding of the resistance of bacteria isolated from food samples.

The procedure involves several well-defined steps to ensure the accuracy and relevance of the results:

Isolation and identification of bacteria: before performing antibiotic sensitivity tests, bacteria must be isolated and properly identified at the species level.

This step involves the use of molecular and biochemical technologies to confirm the presence of pathogenic bacteria and ensure the uniformity of the sample batch.

Establishing antibiotic concentrations: the exact concentrations of antibiotics used in tests must be established according to CLSI (Clinical and Laboratory Standards Institute) guidelines or other relevant international standards.

Antibiotic susceptibility techniques: antibiotic susceptibility tests are performed using standardized methods such as agar diffusion, dilution in liquid media, or automated methods, depending on the specific bacteria and antibiotics tested.

Special attention must be paid to CLSI standards to ensure the comparability of results.

Interpretation and documentation of results: Test results are interpreted according to reference values established by international organizations.

Detailed analysis of antibiotic sensitivity profiles provides essential data for understanding the extent and diversity of resistance among bacteria in the food sector and can serve as a basis for recommendations regarding responsible antibiotic use in agricultural and food practices (25,27).

Identification of resistance genes and mechanisms involved

To better understand antibiotic resistance at the molecular level and to identify resistance genes and mechanisms involved in bacteria isolated from the food sector, the following steps can be taken:

Extraction of bacterial DNA: bacterial DNA is extracted from isolated samples using specialized extraction techniques, ensuring the purity and integrity of the genetic material. This process is essential to obtain reliable and representative genetic sequences.

Genomic sequencing: the extracted DNA undergoes genomic sequencing to obtain a complete picture of the genetic material of bacteria.

Bioinformatic analysis: sequence data is analyzed using bioinformatic software to identify antibiotic resistance genes and determine any associated mutations.

This analysis includes comparison with reference databases to confirm gene identification.

Experimental validation: To validate the results of bioinformatic analysis, experimental tests such as PCR (Polymerase Chain Reaction) are performed to amplify and identify specific genes. This step is essential to confirm the presence of resistance genes identified by genomic sequencing.

Characterization of resistance mechanisms: based on the information obtained from bioinformatic analysis and experimental validation, specific mechanisms of antibiotic resistance are characterized.

This includes identifying the type of resistance (efflux, enzymatic modifications, etc.) and evaluating the expression level of the respective genes.

Interpretation and correlation with sensitivity profiles: the results obtained in identifying resistance genes and mechanisms involved are correlated with antibiotic sensitivity profiles.

This data integration provides a comprehensive understanding of the genomic and phenotypic characteristics of isolated bacteria.

This integrated approach to identifying resistance genes and mechanisms involved makes a significant contribution to understanding antibiotic resistance at the molecular level and can provide crucial information for developing precise and targeted strategies in managing antibiotic resistance in the food sector (25).

The expansion of antibiotic resistance in foodborne bacteria

The expansion of antibiotic resistance in foodborne bacteria indicates persistent pressure on these microorganisms, highlighting the need for a comprehensive and in-depth approach to managing this phenomenon.

The identified resistance mechanisms provide a detailed picture of how bacteria adapt to antibiotic pressure, facilitating the development of effective combating strategies (26).

The expansion of antibiotic resistance in foodborne bacteria represents a major threat to human health, with the potential to affect the effectiveness of treatments and increase the risk of complications.

Close monitoring and regulation are necessary to reduce unjustified antibiotic use in agriculture and to promote responsible food practices (21, 24).

The analysis of variability in resistance among food sources has identified important contributing factors to this phenomenon.

Agricultural practices, including antibiotic use in animal husbandry, have been identified as significant factors.

Additionally, differences in production processes and food hygiene have contributed to variation in resistance between food categories.

This detailed understanding of contributing factors provides the necessary basis for developing effective intervention strategies

aimed at reducing resistance in the food sector (14,26,19).

Implications for public health and food practices

Antibiotic resistance in the food sector has significant implications for public health and food practices.

The expansion of antibiotic resistance in foodborne bacteria represents a major threat to human health, with the potential to affect the effectiveness of treatments and increase the risk of complications.

Close monitoring and regulation are necessary to reduce unjustified antibiotic use in agriculture and to promote responsible food practices (9, 15).

Numerous previous studies have made significant contributions to understanding antibiotic resistance in the food sector.

These researches have examined various aspects, including antibiotic resistance profiles of bacteria isolated from foods, the impact of agricultural practices on resistance development, and the implications of this resistance for human health.

The study conducted by Elder et al. in 2016 explores antibiotic resistance in foodborne pathogens, emphasizing the need for a global approach to managing this issue.

The authors highlight the links between antibiotic use in agriculture and the spread of resistance worldwide (9).

Additionally, Mukherjee et al. (2020) investigate the impact of agricultural practices, particularly soil irrigation, on the development of antibiotic resistance in *Escherichia coli*, exploring connections between irrigation water use and resistance emergence (20).

Research on antibiotic resistance in *E. coli* is complemented by Caruso in 2018, who analyzes antibiotic resistance in *Escherichia coli* isolated from farm animals, examining the evolution of resistance to various classes of antibiotics and highlighting the importance of constant monitoring in the agricultural sector (6).

Another study that contributed to understanding antibiotic resistance in the food sector is "*Antibiotic Resistance in Foodborne Bacteria - An Emerging Public Health Problem*," in which author Komolafe examines antibiotic resistance in foodborne bacteria and highlights the magnitude of the problem as an emerging threat to public health, emphasizing the need for an interdisciplinary approach to counteract this problem (17).

Conclusions

Understanding the dynamics of antibiotic resistance in the food sector is essential for implementing new strategies for managing antibiotic resistance.

The adoption of responsible agricultural practices and rational antibiotic use is necessary to reduce selective pressure on bacteria, thereby minimizing the risk of resistance expansion.

These measures are imperative for protecting public health and for effectively managing a phenomenon evolving in a continuously changing food context.

Continuous monitoring of antibiotic resistance in the food sector is a key element in our efforts to anticipate and manage these emerging threats to human health.

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