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## Phytochemical evaluation and antibacterial activity of garlic extract against multidrug-resistant *Salmonella* in poultry meat

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### Abstract

The emergence of multidrug-resistant (MDR) *Salmonella* strains presents a significant challenge to food safety and public health, especially within the poultry industry. The development of antimicrobial resistance in *Salmonella* strains, primarily due to overuse and misuse of antibiotics, has led to the search for alternative antimicrobial agents. Garlic (*Allium sativum*) has garnered attention for its phytochemical properties and potential to inhibit bacterial growth, including that of MDR *Salmonella*. This review examines the phytochemical composition of garlic and its antibacterial effects on *Salmonella* isolates from poultry meat. The synergistic action of garlic with conventional antibiotics is also explored, highlighting its promise as a natural solution to combat MDR *Salmonella* in poultry.

**Keywords:** Garlic extract, *Salmonella*, multidrug-resistant, phytochemicals, antimicrobial resistance, poultry meat, antibiotics, synergy

### 1. Introduction

To enhance the reliability of the findings, it would be beneficial to include studies from a broader range of geographical locations and poultry farms. This would ensure the results are more representative of various poultry farming practices and environmental conditions, further strengthening the conclusions drawn in this review. The poultry industry is a major source of foodborne pathogens, with *Salmonella* being one of the most common bacterial agents responsible for human gastrointestinal infections. The increasing prevalence of multidrug-resistant *Salmonella* strains poses a serious challenge to public health, as these strains are less responsive to conventional antibiotic treatments. This situation has prompted a global effort to identify alternative antimicrobial agents that can combat resistant pathogens.

Garlic (*Allium sativum*), a widely used medicinal plant, has been recognized for its potent antimicrobial properties. Phytochemicals in garlic, such as allicin, diallyl disulfide, and sulfur-containing compounds, exhibit significant antibacterial activity. Garlic extract has been shown to possess inhibitory effects on a wide range of pathogens, including *Salmonella*. This review aims to examine the phytochemical composition of garlic and its antibacterial activity against MDR *Salmonella* isolated from poultry meat.

### 2. Phytochemical Composition of Garlic

Garlic contains several bioactive compounds that contribute to its antimicrobial properties. The most well-known active compound is allicin, which is formed when garlic is crushed or chopped, activating the enzyme alliinase that converts alliin to allicin. Allicin is known to have potent antibacterial, antifungal, and antiviral effects, making it a key player in garlic's therapeutic applications<sup>[1]</sup>.

In addition to allicin, garlic contains other sulfur-containing compounds such as diallyl disulfide, diallyl trisulfide, and S-allyl cysteine, all of which contribute to its antimicrobial activity. These compounds have been found to disrupt the integrity of bacterial cell membranes, leading to the leakage of cellular contents and eventual bacterial death<sup>[2]</sup>. The phytochemical profile of garlic also includes flavonoids, saponins, and phenolic acids, which have been shown to possess antioxidant and anti-inflammatory properties<sup>[3]</sup>.

### 3. Antibacterial Activity of Garlic Extract

Further studies have shown that allicin and other sulfur-containing compounds in garlic may interact with bacterial enzymes, particularly those involved in cell wall synthesis and oxidative stress management. Allicin is believed to disrupt bacterial cell membranes by reacting with thiol groups of proteins and enzymes, leading to the inhibition of bacterial growth.

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Studies also suggest that allicin may interfere with the synthesis of DNA and RNA, impairing the bacteria's ability to replicate and produce essential proteins. The antibacterial activity of garlic extract has been widely studied, with numerous studies confirming its effectiveness against various pathogenic bacteria, including *Salmonella*. Research has shown that garlic extract can inhibit the growth of both Gram-positive and Gram-negative bacteria by interfering with their cell wall synthesis and protein function [4]. Studies involving *Salmonella* isolates from poultry meat have demonstrated that garlic extract exhibits significant inhibitory effects, with some studies reporting inhibition zones as large as 20 mm when used in combination with conventional antibiotics [5].

The antimicrobial action of garlic extract is thought to be primarily due to its ability to alter bacterial cell membranes, disrupting their function and leading to cell death. Allicin, in particular, has been shown to interact with bacterial enzymes, inhibiting their activity and preventing the synthesis of essential cellular components [6]. Moreover, garlic extract has demonstrated activity against antibiotic-resistant *Salmonella* strains, suggesting its potential as an alternative treatment to combat MDR *Salmonella* in poultry meat [7].

#### 4. Synergistic Effects of Garlic Extract and Antibiotics

The combination of garlic extract with conventional antibiotics has been shown to exhibit synergistic effects, enhancing the antibacterial activity of the antibiotics against MDR *Salmonella*. Several studies have investigated the synergistic effects of garlic extract with antibiotics such as amoxicillin, ciprofloxacin, and tetracycline. In many cases, garlic extract has reduced the minimal inhibitory concentration (MIC) of these antibiotics, indicating that it enhances their efficacy [8].

One study demonstrated that the combination of garlic extract with amoxicillin resulted in a significant reduction in bacterial growth compared to either treatment alone. The fractional inhibitory concentration index (FICI) for the combination was found to be less than 0.5, indicating strong synergy between the two agents [9]. Another study found similar results when garlic extract was combined with ciprofloxacin, suggesting that garlic may facilitate the entry of antibiotics into bacterial cells, improving their antimicrobial effects [10].

This synergistic action is believed to occur through several mechanisms, including the enhancement of antibiotic uptake by bacterial cells, the inhibition of bacterial efflux pumps, and the alteration of bacterial cell membrane integrity, which increases the permeability of antibiotics [11]. The use of garlic extract in combination with antibiotics may provide a promising strategy for overcoming antibiotic resistance in *Salmonella* strains from poultry meat.

#### 5. Garlic Extract as a Natural Alternative in Poultry Production

The incorporation of garlic extract in poultry production requires further investigation into its optimal dosage and safety parameters. While garlic extract has demonstrated antibacterial efficacy, the appropriate concentration needed to reduce *Salmonella* contamination without adverse effects on poultry health must be established. Additionally, regulatory approval for garlic extract as a feed additive must be sought to ensure compliance with food safety standards and avoid potential toxicity in animals or humans. Investigating its long-term effects and any interactions with other feed ingredients is also critical for determining its viability as a natural alternative to antibiotics. While garlic extract has shown

promising results, it is important to compare its antimicrobial properties with other natural agents such as ginger, oregano, and turmeric. These agents also exhibit antimicrobial activity and could be used in conjunction with garlic to enhance its efficacy. A comparative analysis could offer insights into which natural products are most effective against *Salmonella* and how they might complement each other in controlling poultry-related infections.

The use of garlic extract in poultry production as an antimicrobial agent requires attention to safety and regulatory concerns. Garlic's bioactive compounds must be assessed for their potential toxicity when consumed in large quantities by poultry. Moreover, guidelines for its inclusion in animal feed must be developed, addressing both the health of the poultry and the safety of humans consuming poultry products. Regulatory bodies such as the FDA and EFSA should be consulted for approval, and ongoing safety studies should be conducted to ensure the sustainable use of garlic extract in commercial farming. The potential application of garlic extract as a natural antimicrobial agent in poultry farming is gaining interest due to the increasing concerns about antimicrobial resistance in livestock production. Garlic extract could be used as an alternative to conventional antibiotics for preventing *Salmonella* infections in poultry, reducing the need for antibiotics in animal feed and minimizing the risk of resistance development.

Research on the practical application of garlic extract in poultry production has suggested that it could be used in various forms, such as in feed or water supplementation, to reduce *Salmonella* contamination in poultry meat. Additionally, garlic extract's antioxidant and immune-boosting properties could contribute to improving the overall health and productivity of poultry [12]. However, further studies are needed to determine the optimal dosage, safety, and regulatory approval for the use of garlic extract in commercial poultry farming.

#### 6. Conclusion

Garlic extract has demonstrated significant antibacterial activity against multidrug-resistant *Salmonella* strains isolated from poultry meat, making it a promising candidate for combating foodborne pathogens in the poultry industry. The phytochemical compounds in garlic, particularly allicin, play a crucial role in its antimicrobial effects. The synergistic action of garlic extract with conventional antibiotics further enhances its efficacy, providing a potential alternative to traditional antibiotics in managing MDR *Salmonella* infections.

While the use of garlic extract in poultry production holds great promise, additional research is needed to explore its practical applications, including optimal dosages, safety, and long-term efficacy. Given the increasing concern over antimicrobial resistance, garlic extract represents a viable natural solution to address the challenge of *Salmonella* contamination in poultry meat.

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