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Antimicrobial and molecular effects of cinnamic acid and magnetized water on pathogenic bacteria in poultry meat: a multi-approach applied study

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Abstract

Objective

Escherichia coli, Salmonella spp., and Staphylococcus aureus are among the most important pathogenic bacteria that contaminate poultry meat. One of the main challenges in the field of food safety is this food contamination. Today, antibiotic resistance is increasing day by day. For this reason, we must move towards using alternative antimicrobial approaches based on natural compounds more and more. Therefore, the aim of this study was to study the individual and synergistic antimicrobial and molecular effects of 1% cinnamic acid and magnetized water on common poultry pathogens under refrigerated storage conditions.

Materials and methods

The samples of fresh chicken meat naturally contaminated with target bacteria were treated in four conditions, namely, cinnamic acid (G1), magnetized water (G2), the mixture of the two (G3), and the control group (G4) immersed in sterile saline. Selective media were used to enumerate microbial loads at 0, 12 and 24 hours. Agar well diffusion was used to determine antimicrobial activity and PCR and gel electrophoresis were used to determine molecular changes to ascertain DNA integrity of target bacteria.

Results

The greatest reduction in bacteria was observed with the combined treatment (G3), where counts of the bacteria E. coli, Salmonella spp. and S. aureus were 52.3, 15.5 and 42 CFU/g at 24 hours, respectively, compared to higher counts in the control (11.55, 4.65, and 67.1 CFU/g). G3 (14.00 mm in the case of E. coli) showed the widest inhibition zones, which showed high synergistic antimicrobial activities. Cinnamic acid on its own had a moderate level of effectiveness whereas on its own, magnetized water was less effective. The outcomes of the electrophoresis revealed that bacterial DNA was significantly degraded by G3, especially in Salmonella spp. and this could be indicating the presence of genotoxic effects of the combined treatment.

Conclusion

The combination of cinnamic acid and magnetized water could be significantly used as a microbial suppressive agent in poultry meat, which has potential to replace conventional preservation with a natural and safe preservative. The results endorse their inclusion as a part of meat preservation measures to enhance food safety and fight antimicrobial resistance.

Keywords: cinnamic acid, magnetized water, poultry meat safety

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Introduction

Livestock production in general and domestic chicken production in particular plays a vital socio-economic role for people living in low-income countries of Africa and Asia (Mohamadinejad et al., 2024; Khezri et al., 2025; Mohammadabadi et al., 2025a). Domestic chickens are widely distributed avian species around the world, due to their short generation interval and adaptability in a wide range of agro ecologies (Mohammadifar and Mohammadabadi, 2017; Khabiri et al., 2025; Mohammadabadi et al., 2025b). The domestic chickens provide high quality protein and income for the poor rural households and are the most widely kept livestock species in the world (Mohammadabadi et al., 2010; Mohammadifar and Mohammadabadi, 2018; Mohammadabadi et al., 2024). This is due to the presence of the valuable traits of chicken like disease resistance, adaptation to harsh environments and ability to utilize poor quality feeds (Shahdadnejad et al., 2016; Khabiri et al., 2023; Mohammadabadi et al., 2025c). Moreover, poultry meat is ranked among the most essential sources of animal protein in the world because it has a high nutritional value, is easy to prepare, and digest, among other factors, which makes it a major preference among many consumers (Tsaloumi et al., 2023; FAO, 2021). As the consumption of these meats increases, many issues associated with the quality of meat and its safety also arise, specifically, microbial contamination, which directly impact the shelf life and health of consumers (Bintsis, 2017; Cerveny et al., 2009). Salmonella, Escherichia coli, and Staphylococcus aureus are the pathogenic bacteria that pose significant health risks, leading to serious intestinal diseases and in a few cases, causative health complications (Phan et al., 2025; Malabadi et al., 2024; Yada, 2023). It is aggravated by the fact that the widespread emergence of bacterial resistance to antibiotics is caused by the excessive and uncontrolled application of antibiotics in poultry farms (Abreu et al., 2023). To counter such challenges, there has been an increase in interest in using natural antimicrobial compounds, including phenolic-based compounds, cinnamic acid, which has been shown to be effective in preventing the growth of different pathogenic bacteria through the disruption of bacterial cell walls and the inhibition of important enzymes (Dembińska et al., 2025; Di Pasqua et al., 2007; Takó et al., 2020). It has been established that cinnamic acid and its forms have the potential to enhance the food safety by decreasing the occurrence of microbial contamination (Zhang et al., 2025; Tian et al., 2025; Zawiła et al., 2025). Additionally, magnetized water has also received the growing research interest because of its potential impacts on the physical and chemical characteristics of water, including the improved ionization and permeability, which impact microbial activity (Shahveh et al., 2025). In the recent research, it has been shown that magnetized water can assist in decreasing the development of some bacteria as well as in improving the quality of agricultural and food products (Dobránszki, 2023). Nevertheless, there is a knowledge gap on the synergistic effect of cinnamic acid and magnetized water when used in combination against pathogenic bacterium in poultry meat. This paper seeks to fill this gap by coming up with effective natural methods of improving meat safety and to increase its quality. The importance of this research is that it would offer healthy and environmental-friendly alternatives to the traditional antibiotics, economic losses linked to the microbial contamination of poultry meat, and technological development of poultry and safe food production.

Materials and methods

Study location: The Study was carried out at the Microbiology Laboratory of the Department of Agricultural Biotechnology Techniques of Al-Kut Technical Institute, which is one of the affiliated institutes of Middle Technical University -Iraq. The study has been conducted based on the available facilities and research infrastructure of the department in line with the existing scientific guidelines governing applicative studies in food safety and pathogenic microbiology.

Culture media: The isolation and enumeration of target bacteria, such as MacConkey agar, Escherichia coli, SS agar, Salmonella spp., and Mannitol Salt Agar, Staphylococcus aureus, were performed using selective agar media, which were prepared in accordance with the standard microbiological procedures (Cappuccino & Welsh, 2019; Benson, 2020).

Poultry meat samples: The fresh samples of chicken meat were taken in a certified local slaughterhouse and then transported in sterile and insulated containers at the microbiology laboratory at a temperature of not more than 4 o C with ice packs. At the arrival, 10 g of each sample was aseptically combined with 90 mL of sterile physiological saline (0.85% NACl). The homogenates were diluted and spread on the above selective media in a series. Colony morphology was used to identify presumptive colonies after incubating the incubation at 37 o C that lasted between 24 and 48 hours. This test confirmed that the meat samples are naturally contaminated with Salmonella spp, E. coli and S. aureus (Wardhana et al., 2021).

Cinnamic acid: Pure cinnamic acid (purest, 98% purity) was purchased at Sigma-Aldrich. Distilled water (100 ml) was added and continuous magnetic stirring was carried out until it was fully dissolved. This concentration was chosen because prior researches have shown that they have antimicrobial effects against foodborne pathogens (Sova, 2012).

Magnetized water: The distilled water was taken through a commercial magnetization system that had a static magnetic field of 1500 Gauss and allowed to pass through a commercial magnetization system to produce magnetized water that is used within a period of 60 minutes. Physicochemical parameters, such as pH, E C, and ionization potential, were measured by calibrated analytical tools after the treatment. Such alterations are said to increase the antimicrobial activity by rearranging the structure of water and ion dynamics (Shihab et al., 2020).

Treatment design: Naturally contaminated chicken meat samples were fresh and the samples did not contain any artificial inoculation. Forty-eight samples were taken and randomly grouped in four groups (12 samples each) such as Group 1 treated with 1-percent cinnamic acid solution, Group 2 treated with magnetized water, Group 3 treated with a mixture of cinnamic acid and magnetized water, and Group 4 (control) treated with sterile physiological saline (0.85per cent NaCl) without the presence of any active agents. Ten grams of each sample were placed aseptically in 90 mL of the respective treatment solution at room temperature (25 ± 2 °C) and gently agitated to facilitate even contact of the meat surface with the treatment. Excess solution was wiped off partially using sterile gauze after the immersion and all samples were kept at 4 °C.

Microbial evaluation over time: Samples were maintained at 4 °C and microbiological analysis was carried out at 0, 12, and 24 hours after the treatment. Three replicates were used at every time point per group of treatment, to guarantee statistical reliability. A total of 10 g of meat sample was aseptically homogenized with 90 mL of sterile physiological saline (0.85% NaCl) in the case of each replicate. Serial ten-fold dilutions were next made and 0.1 ml aliquots of the relevant dilutions were inoculated on selective agar media. The plates were incubated within 24-48 hours at 37 °C, then the colony-forming units (CFU) were counted and the results reported as CFU per gram of meat sample (Cappuccino & Welsh, 2019).

Well diffusion method: The agar well diffusion method was applied in determining the antibacterial activity of each treatment. Salmonella spp., E. coli, and S. aureus fresh cultures were obtained after purification of bacterial colonies obtained on the treated meat samples. Equal quantities of each of the bacterial suspensions were evenly spread on the Mueller-Hinton agar plates. Agar was aseptically punched with 6 mm wells using a sterile cork borer and 100 µL of corresponding test solution (cinnamic acid, magnetized water, or the mixture of the two) was added to each well. A negative control was the distilled water. The plates were incubated at 37 o C during 24 hours and the diameter of the inhibitory zones was measured in millimeters to determine the level of antimicrobial effect (CLSI, 2015).

PCR confirmation: After the treatment was applied, the presence of specific bacterial genes after 24 hours was detected by Polymerase Chain Reaction (PCR) with the help of genus-specific primers (invA gene in Salmonella spp., uidA gene in Escherichia coli, and nuc gene in Staphylococcus aureus) to identify the presence of the target bacteria and to estimate possible loss of the pathogenicity markers. The samples were swabbed on the meat surface after 24 hours of cold storage after treatment, and molecular analysis was used to determine bacterial persistence (Saiki et al., 1988; Postollec et al., 2011).

Statistical analysis: SPSS software (version 25) was used for data analysis. Three-way ANOVA was used in the first experiment to examine the effects of bacterial species, treatment groups, and exposure time, as well as the interaction between them. In the second experiment, the data on inhibition zone diameters has been subjected to one-way ANOVA followed by post hoc Tukey HSD test to conduct numerous comparisons between treatment means. The third experiment that included bacterial identification was interpreted descriptively and not through inferential statistics. The level of statistical significance was established at $p \leq 0.05$ (Montgomery, 2017; Field, 2018).

Results and discussion

Microbial evaluation over time: The results show statistically significant different treatments ($p<0.05$) between and among treatments on the mean counts of pathogenic bacteria (E. coli, Salmonella spp., and Staphylococcus aureus) in poultry meat (Table 1) in case of individual and combined treatments of cinnamic acid and magnetized water during refrigerated storage (0, 12, and 24 hours). First, the combination treatment (G3) exhibited the best bacterial killing in all the test species. In 24 hours, the means in this group were 5.23 x 10 7 E. coli, Salmonella spp. and S. aureus CFU/g. Conversely, the control group (G4) that contained immersion in sterile saline displayed significantly greater bacterial counts of 11.55, 4.65, and 6.75 x 10 1 CFU/g, respectively. These results suggest the synergetic effect of cinnamic acid and magnetized water in inhibiting the growth of microorganisms during chilled storage. This synergism corroborates previous research that indicates that phenolic acid like cinnamic acid has a potent antimicrobial effect by weakening bacterial cell walls and by inhibiting important enzymes in the metabolism of bacteria (Jaramillo Jimenez et al., 2024; Zhang et al., 2025; Zawiła et al., 2025). Also, magnetized water is reported to promote the efficacy of antimicrobials by modifying the physicochemical characteristics of water, such as ionization and conductivity, which affect the membrane stability of bacteria (Moussa et al., 2025). Application of cinnamic acid alone (G1) also showed a moderate effect of reducing the number of microbes and against Salmonella spp. and E. coli. Nevertheless, the antimicrobial activity against S. aureus was so weaker, probably as a result of its known resistance to environmental pressure. Such results can be compared with those made by Sova (2012), who has observed the variable sensitivity of various pathogens to phenolic acids. Conversely, the sole use of magnetized water (G2) did not significantly lower the number of bacteria, and this number did not change significantly between the time. It means that although magnetized water can potentially change the characteristics of the medium, it has no direct antimicrobial activity by itself. Its application seems to be supportive when combined with active antimicrobial agents. Additionally, there was a statistically significant temporal effect ($p = 0.029$) and the overall decrease in bacterial load was between 6.51 to 5.20×10^1 CFU/g. This implies that treatments become more effective with time, which justifies their application in short-term meat preservation under refrigerated conditions. The differences in the responses of bacteria to treatments observed can possibly be explained by microbiological and physiological variables. Salmonella spp. was the most sensitive, which could be explained by a thinner peptidoglycan layer and higher vulnerability to external agents.

Table 1. The Individual and Combined Effects of Cinnamic Acid and Magnetized Water on the Reduction of Pathogenic Bacteria in Poultry Meat x × 10^1 CFU/g (Mean ± SD)

Bacteria	Treatment	Store/hour			Bacteria* Treatment
		0	12	24	
E. coli.	G1	9.03±1.78	7.43±1.50	6.80±0.72	7.75±1.57
	G2	9.36±2.28	9.00±2.64	9.00±2.62	9.12±2.19
	G3	9.33±1.13	4.11±1.08	2.26±0.64	5.23±0.20
	G4	9.00±2.00	11.66±1.52	14.00±2.64	11.55±2.83
Salmonella spp.	G1	4.03±1.18	2.42±1.50	1.80±0.62	2.75±1.57
	G2	4.36±0.28	4.00±0.08	4.00±0.55	4.12±1.78
	G3	4.33±0.13	0.33±0.01	0.00±0.00	1.55±0.23
	G4	4.00±1.22	4.67±0.46	5.30±0.57	4.65±1.22
S. aureus.	G1	6.00±1.12	4.43±1.50	3.80±0.70	4.74±1.49
	G2	6.36±2.28	6.00±2.64	6.00±0.19	6.12±2.19
	G3	6.30±0.14	4.00±1.00	2.31±0.05	4.20±1.15
	G4	6.00±1.00	6.81±0.65	7.45±0.16	6.75±1.22
		P-Value:0.903			P-Value:0.299
Bacteria* Time		0	12	24	Average Bacteria
E. coli		9.28±0.12	8.10±0.07	8.08±0.31	8.48±0.11
Salmonella spp.		4.11±0.03	2.85±0.13	2.78±0.04	3.24±0.11
S. aureus		6.17±0.21	4.83±0.08	4.28±0.19	5.09±0.05
		P-Value:0.992			P-Value:0.001
Treatment* Time		0	12	24	Average Treatment
G1		6.36±1.03	4.76±0.03	4.13±1.00	5.08±0.05
G2		6.70±0.02	6.33±0.12	6.30±0.15	6.44±0.12
G3		6.66±0.17	2.32±0.04	2.08±0.17	3.68±0.10
G4		6.33±0.01	7.64±0.09	8.59±0.06	7.51±0.08
		P-Value:0.001			P-Value:0.001
		Average Time			
		0	12	24	
		6.51±0.01	5.35±0.22	5.20±0.14	
			P-Value:0.029		

G1 cinnamic acid 1% cinnamic acid; G2 magnetized water; G3 cinnamic acid and magnetized water; G4 control (treated with sterile physiological saline, 0.85% NaCl). The number of bacteria is determined as the mean standard deviation (×10^1 CFU/g). Sig. = Statistical significance measured by three-way ANOVA with P 0.05, which measured the effects of bacterial species and treatment groups and storage periods (3 hours, 0, 12, and 24 hours).

It is probable that cinnamic acid disrupts cellular ion balance and osmotic pressure, thereby leading to cellular lysis and microbial death, which are the likely outcomes of cinnamic acid and magnetized water (performed singly and in combination) as safe and effective natural agents to prevent microbial contamination in poultry product. These alternatives have the potential to decrease the use of traditional antibiotics and alleviate the problem of antimicrobial resistance which is progressively growing in the animal food sector (Ruwizhi et al., 2020; Abd El-Hack et al., 2022).

Antibacterial activity: Table 2 shows clearly that cinnamic acid and magnetized water have important independent and combined effects on the inhibition of the growth of three pathogenic bacteria that are commonly present in poultry meat: Escherichia coli, Salmonella spp., and Staphylococcus aureus. The best inhibition zones were observed with the combination of 1% cinnamic acid and magnetized water (G3), where the best inhibition zones were 14.00 mm with E. coli, 13.08 mm with S. aureus, and 11.05 mm with Salmonella spp. This implies that the use of cinnamic acid and magnetized water in an interactive manner results in a synergistic effect that leads to a stronger antimicrobial performance in comparison to when either of the two agents are used independently. Cinnamic acid (G1) reduced to magnetized water (G2) demonstrated significant antibacterial effects as it exhibited a range between 9.40 mm and 11.24 mm, and 6.98 mm and 8.00 mm, respectively. The control treatment (G4), which is the distilled water, did not have any inhibitory effect, thus supporting the fact that the antimicrobial effect observed is due to the applied treatments. These results align with previous studies that support the antimicrobial activity of cinnamic acid that is believed to work via cell wall disruption and interference with intracellular metabolic activities to result in cell death or growth prevention (Gurtler and Mai, 2014; Zhang et al., 2025). The physicochemical alterations caused by the magnetic field to the water molecules are credited to the antimicrobial activity of magnetized water. These changes in the structure of water and ion action increase its antimicrobial activity (Minoretti & Emanuele, 2024). It is important to note that cinnamic acid combined with magnetized water saw a significant enhancement of the antibacterial effect that could be due to the fact that, the magnetized water could help to increase the penetration of active compounds into bacteria cells or enhance their stability to further ensure that bacterial growth is countered, These findings bring to the fore the possible use of cinnamic acid and magnetized water, particularly in combination, as safe and effective natural agents to curb the bacteria contamination in poultry product. They can be used to decrease the use of standard antibiotics and alleviate the increasing problem of antimicrobial resistance in animal food production (Ruwizhi et al., 2020).

Table 2. Zone of inhibition (mm) for E. coli, Salmonella spp., and S. aureus treated with cinnamic acid, magnetized water, and their combination

Treatment	Inhibition (Mm)		
	E. coli	***Salmonella spp.***	***S. aureus***
G1	11.24^{b}±0.01	10.17^{a}±0.05	9.40^{b}±0.03
G2	7.01^{c}±0.01	6.98^{b}±0.01	8.00^{b}±0.20
G3	14.00^{a}±0.03	11.05^{a}±0.02	13.08^{a}±0.01
G4	0.00^{d}±0.00	0.00^{c}±0.00	0.00^{c}±0.00
Sig.	0.05	0.05	0.05

G1 = 1% cinnamic acid; G2 = magnetized water; G3 = combination of cinnamic acid and magnetized water; G4 = control (distilled water). Sig. = Statistical significance at P ≤ 0.05 (based on ANOVA).

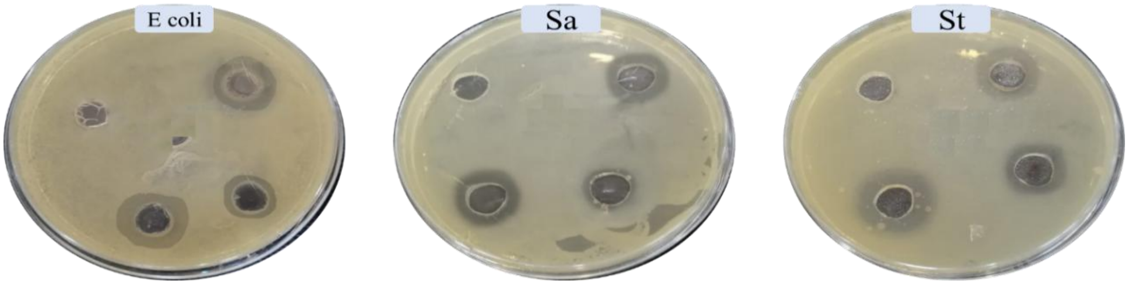

Figure 1. Evaluation of antibacterial efficacy with the well diffusion technique against Escherichia coli (E. coli), Salmonella spp. (Sa), and Staphylococcus aureus (St). Distinct inhibition zones around the wells with various treatments (cinnamic acid, magnetized water, and their combination) demonstrate the degree of bacterial growth inhibition

Gel electrophoresis results for bacterial DNA profiles: The gel electrophoresis run to assess the effect of different treatments on the DNA integrity of the three common bacterial strains, which are, Escherichia coli, Salmonella spp., and Staphylococcus aureus, show clear variations in the intensity and thickness of the bands between the four experimental treatments (G1, G2, G3, and G4) that were used simultaneously. The untreated control group (lane G4) was used as a control in terms of all strains and it always had the most visible and highest density DNA bands, which indicates a high concentration of genetic material when there is no intervention. Lane G3, on the contrary, had the lowest band intensity in all strains with Salmonella recording almost total disappearance of the band signifying a severe visual decrease in the concentration of DNA. This could indicate that the therapy applied in G3 could have had a profound inhibitory effect on the growth of bacteria or that it could have compromised the genetic material to a certain/total extent. The intermediate band intensities were observed in lanes G1 and G2, which were between the untreated control (G4) and G3 meant that the treatments used in the lab on these groups had a moderate effect in lowering the DNA content, though not as significant as in G3. This gradual decrease of the band density is a visual representation of the effect of each treatment but this is not to say that these are based on quantitative statistical analysis rather than qualitative ones. Interpretatively, the results are similar to those of recent research. As an example, as Malheiro et al. (2023) described, some chemical or bioactive compounds may destabilize the bacterial DNA, which is then destroyed or fragmented. In the same manner, Anandhi et al. (2014) observed that the efficacy of antimicrobial therapy could be estimated early on through the decrease in the DNA band intensity in the electrophoresis gels, as a visual indicator of the bacterial DNA content. The review by Vaiwala and Sharma et al. (2022) also reaffirmed that band thickness in electrophoretic analysis is a good qualitative measure of the DNA concentration, hence its utilization in preliminary assessments of treatment efficacy, particularly where statistical methods cannot be used. In terms of varying effects of bacterial strain, emphasized that bacterial response on antimicrobial agents depends on cell wall structure as a determinant. Gram-negative bacteria like E. coli and Salmonella have less rigid outer membranes and are therefore more susceptible to attack than Gram-positive ones like Staphylococcus aureus, which have more peptidoglycan layers that are thick and impart greater resistance to penetration.

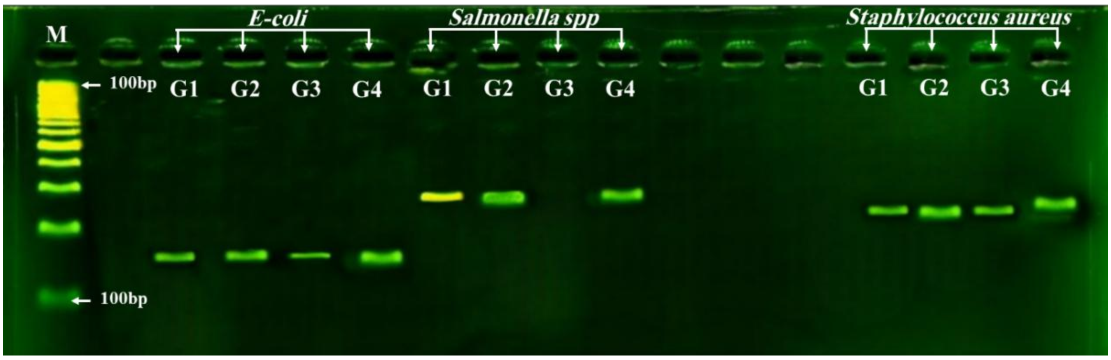

Figure 2. PCR amplification products that were positive by demonstrating the presence of the following bacterial genes (uidA in E. coli, invA in Salmonella spp., and nuc in Staphylococcus aureus) in treated poultry meat samples after 24 hours. Bands denote the existence of target gen

Conclusions: The study findings proved that the treatments used cinnamic acid, magnetized water, and a combination of both cinnamic acid and magnetized water were good in reducing the number of pathogenic bacteria present on poultry meat demonstrating different levels of antibacterial effectiveness. The combination treatment had the best efficacy as it had the biggest reduction of bacterial growth and the highest area of inhibition. The usefulness of these treatments was also supported by molecular identification with PCR which showed a reduction or loss of the specific bacterial genes of interest. These results justify the possibility of such natural interventions being as safe and promising alternatives to improve the meat safety and reduce the risks of microbes.

Author's contributions

Collection and organization of data were mainly done by Ali Ahmed Khalaf. Mustafa Ressan Kazem helped in laboratory work and discussion of the results. Dheyab D. Radhi was to conduct statistical analysis and review of the manuscript. The overall supervision involved all the authors.

Data availability statement

Data are available from the authors upon reasonable request.

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Ethical considerations

The ethical approval and animal care procedures were undertaken as per the recommendations of the local ethics commission of the Technical Institute, Kut, Middle Technical University.

Conflict of interest

The authors have indicated that they have no conflict of interest.

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اثرات ضدمیکروبی و مولکولی اسید سینامیک و آب مغناطیسی‌شده بر باکتری‌های بیماری‌زای موجود در گوشت طیور: یک مطالعه کاربردی چندرویکردی

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چکیده

هدف: باکتری‌های اشرشیا کلی (Escherichia coli)، گونه‌های سالمونلا (Salmonella spp.) و استافیلوکوکوس اورئوس (Staphylococcus aureus) از مهم‌ترین عوامل بیماری‌زایی هستند که موجب آلودگی گوشت طیور می‌شوند و این آلودگی یکی از چالش‌های اساسی در حوزه ایمنی مواد غذایی به شمار می‌رود. امروزه، مقاومت آنتی‌بیوتیکی به‌طور فزاینده‌ای در حال افزایش است؛ ازاین‌رو، گرایش به استفاده از رویکردهای ضدمیکروبی جایگزین مبتنی بر ترکیبات طبیعی اهمیت بیشتری یافته است. بنابراین، هدف از این مطالعه بررسی اثرات ضدمیکروبی و مولکولیِ منفرد و هم‌افزایانه‌ی اسید سینامیک ۱٪ و آب مغناطیسی‌شده بر پاتوژن‌های شایع گوشت طیور تحت شرایط نگهداری در دمای یخچال بود.

مواد و روش‌ها: نمونه‌های گوشت مرغ تازه که به‌طور طبیعی به باکتری‌های هدف آلوده بودند، تحت چهار تیمار شامل اسید سینامیک (G1)، آب مغناطیسی‌شده (G2)، ترکیب اسید سینامیک و آب مغناطیسی‌شده (G3) و گروه شاهد (G4) که در محلول سالین استریل غوطه‌ور شده بود، قرار گرفتند. برای شمارش بار میکروبی در زمان‌های ۰، ۱۲ و ۲۴ ساعت از محیط‌های کشت انتخابی

استفاده شد. فعالیت ضدمیکروبی به‌وسیله‌ی روش انتشار در چاهک آگار تعیین گردید و به‌منظور بررسی تغییرات مولکولی و ارزیابی سلامت DNA باکتری‌های هدف، از واکنش زنجیره‌ای پلیمراز (PCR) و الکتروفورز ژل استفاده شد.

نتایج: بیشترین کاهش جمعیت باکتریایی در تیمار ترکیبی G3 مشاهده شد؛ به‌طوری‌که شمار E. coli، .Salmonella spp و S. aureus پس از ۲۴ ساعت به‌ترتیب ۵۲/۳، ۱۵/۵، و ۴۲ CFU/g بود، در حالی‌که این مقادیر در گروه شاهد به‌ترتیب ۱۱/۵۵، ۴/۶۵، و ۴۲ CFU/g گزارش شد. تیمار G3 بیشترین قطر هاله عدم رشد (۱۴ میلی‌متر در مورد E. coli) را نشان داد که بیانگر فعالیت ضدمیکروبی هم‌افزای قوی بود. اسید سینامیک به‌تنهایی اثرگذاری متوسطی داشت، در حالی‌که آب مغناطیسی‌شده به‌صورت منفرد اثربخشی کمتری نشان داد. نتایج الکتروفورز حاکی از تخریب قابل‌توجه DNA باکتریایی در تیمار G3، به‌ویژه در .Salmonella spp بود که می‌تواند نشان‌دهنده‌ی اثرات ژنوتوکسیک تیمار ترکیبی باشد.

نتیجه‌گیری: ترکیب اسید سینامیک و آب مغناطیسی‌شده می‌تواند به‌طور مؤثری به‌عنوان یک عامل مهارکننده میکروبی در گوشت طیور مورد استفاده قرار گیرد و این ترکیب پتانسیل جایگزینی روش‌های نگهداری متداول با یک نگه‌دارنده طبیعی و ایمن را دارد. نتایج این مطالعه، استفاده از این ترکیب را به‌عنوان بخشی از راهکارهای حفظ و نگهداری گوشت به‌منظور افزایش ایمنی مواد غذایی و مقابله با مقاومت ضدمیکروبی تأیید می‌کند.

کلمات کلیدی: آب مغناطیسی‌شده، اسید سینامیک، ایمنی گوشت طیور

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