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Brief Report

Unveiling the Potency and Harnessing the Antibacterial Activities of Plant Oils against Foodborne Pathogens

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Abstract: The rising concerns regarding antibiotic resistance and the harmful effects of synthetic preservatives have led to an increasing interest in exploring natural alternatives. Plant oils have been traditionally used for their antimicrobial properties, but systematic investigations into their efficacy against foodborne pathogens are necessary for potential applications in food preservation. This study aimed to evaluate the antibacterial potential of various plant oils (neem, coconut, castor, and olive oil) against common foodborne pathogens and analyze their chemical composition using gas chromatography–mass spectrometry (GC-MS). The oils were tested against foodborne pathogens using the disk diffusion method. Minimum inhibitory concentrations (MICs) were determined to assess the potency of the oils. GC-MS was employed to identify the compounds present in each oil. Neem oil exhibited significant antibacterial activity against all tested pathogens, with pronounced effects against *Staphylococcus aureus* and *Bacillus cereus*. Coconut oil showed notable activity against *Listeria monocytogenes*. Castor oil displayed moderate activity, while olive oil exhibited minimal antibacterial effects. The GC-MS analysis revealed a diverse array of compounds in neem oil, which is likely to contribute to its potent antibacterial properties. Neem and coconut oils, owing to their rich bioactive components, emerged as promising candidates for the development of natural antimicrobial agents. These brief findings support the potential application of plant oils in food preservation and emphasize the need for further research into understanding the underlying mechanisms and optimizing their use.

Keywords: essential plant oils; antibacterial activity; gas chromatography–mass spectrometry (GC-MS); foodborne pathogens; minimum inhibitory concentrations (MICs)

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1. Introduction

The impact of microorganisms on food spoilage has captured the attention of food producers and those concerned with sustainable food consumption [1,2]. Throughout history, foodborne diseases have plagued humanity, affecting millions annually through a diverse range of pathogens and physical and chemical agents [3]. The visual symptoms exhibited by spoiled food provide clear evidence of the spoilage process. Biochemical reactions, such as oxidation, which commonly occur during food processing and storage, contribute to reducing product shelf life and the deterioration of flavor, texture, and color [4]. The proliferation of pathogenic bacteria and fungi in food threatens its preservation and contributes to the emergence of foodborne diseases worldwide [1]. Increasing consumer apprehension regarding the side effects of chemical and synthetic preservatives has fueled the demand for natural alternatives [5]. Thus, there is an urgent need to identify natural substances

with broad-spectrum antioxidant and antibacterial properties capable of replacing these chemicals and potentially enhancing perishable foods' quality and shelf life [6].

Plant oils (POs) possess inherent antibacterial properties due to their volatile nature and distinct aroma [1]. These oils contain various bioactive compounds that directly target pathogens, making them potential sources of novel antibacterial agents that are particularly effective against bacterial pathogens [7]. The composition of plant oils can vary depending on the plant species, subspecies, and extraction method, with major components often comprising a significant percentage (up to 85%) and trace components occurring in smaller amounts. These oils consist of cyclic and acyclic compounds, including alcohols, esters, phenols, ketones, lactones, aldehydes, and oxides. Phenolic compounds are commonly associated with the antibacterial properties of plant oils, although minor compounds may also contribute to their efficacy through potential synergistic effects [5]. Extensive research has demonstrated the broad-spectrum antibacterial activity of plant oils, although their effectiveness can vary across different pathogens [8]. For example, Neem oil is reported to contain over 140 bioactive compounds, the most abundant of which are Azadirachtin, nimbin, and nimbidine. These compounds make these extracts useful for many applications, including the elimination of harmful bacteria in the poultry industry [9] and the destruction of biofilms [10]. Similarly, castor oil was shown to be effective against *E. coli* (Gram-negative) and *Staphylococcus aureus* (Gram-positive) bacteria due to its rich fatty acid content, especially ricinoleic acid [11]. Additionallyr, coconut oil contains variety of fatty acids, including caprylic, capric, lauric (the major one constituent of over 50%), myristic, palmitic, stearic, oleic, and linoleic acid, and has been exploited to tackle pathogenic bacteria in aquaculture [12]. Although not an essential oil, virgin olive oil is a carrier oil that has been shown to possess numerous health benefits, due to its richness in phenolic compounds [13]. Some reported benefits include its involvement in the inhibition of inflammatory processes and the prevention of liver damage through the reduction in oxidative stress, among others [13]. Other plant oils such as tea tree oil, cinnamon bark oil, thyme oil, peppermint oil, and oregano oil have also exhibited potent antibacterial activity against various pathogens, including *Staphylococcus aureus*, *Escherichia coli*, *Salmonella* spp., and *Listeria monocytogenes* [1,14–17].

In the wake of escalating concerns about antimicrobial resistance and the negative impacts of synthetic preservatives, interest in natural alternatives has surged. Plant oils, long revered for their antimicrobial properties, present a promising avenue for exploration, particularly for food preservation applications. Although numerous studies have demonstrated the broad-spectrum antibacterial activity of plant oils and their bioactive components against diverse foodborne pathogens [14,18], there remains a significant gap in systematic investigations aimed at potential food preservation applications. Recent work has started to bridge this gap; for example, Sánchez-González et al. [19] found that oregano oil, when incorporated into edible films, could significantly reduce bacterial contamination in fresh produce. Similarly, Wu et al. [20] reported that the use of cinnamon oil led to a substantial reduction in mold growth in bread over extended periods compared to controls. Building on this emerging body of research, the present study aims to evaluate the antibacterial efficacy of coconut, neem, castor, and olive oils against foodborne bacterial pathogens and to identify the bioactive compounds responsible for their antibacterial activities.

2. Materials and Methods

2.1. Plant Oils

A total of four plant species were used in this study, namely neem (seed), castor (seed), coconut (fruit), and Indian olive (whole fruit). The plants were collected from various sources. Castor plant seeds were obtained from the Seed Centre at Tamil Nadu Agriculture University, while coconut fruits were acquired from the local market. Neem fruits were collected aseptically from local farmers, and Indian olive fruits were sourced from Nandi Hills, Bangalore. These plants were selected based on their local ethnobotanical

significance (Table 1), particularly their traditional medicinal uses. All plant parts were collected and stored under aseptic conditions until the plant oils were extracted.

Table 1. Ethnobotanical data of plant oils used during the experiment.

Plant Species	Family	Local Name	Common Name	Plant Parts Used
Azadirachta indica	*Meliaceae*	Vembu, Sengumaru, Veppa	Neem	Seed
Ricinus communis	*Euphorbiaceae*	Amanakku, Kottamuthu	Castor	Seed
Cocos nucifera	*Arecaceae*	Tennai, Tengku	Coconut	Fruit
Elaeocarpus floribundus	*Elaeocarpaceae*	Veralikkai	Indian Olive	Whole fruit

To extract the oils, neem and castor seeds underwent pressing using industrial expellers to extract their oils. The extraction of coconut oil involved boiling and cooling the coconut milk, whereas the olive oil was obtained using an industrial decanter and a series of centrifugation processes. All the oils used in the study were extracted and processed from the local oil industry. Commercial oils were not utilized due to the presence of preservatives that could potentially interfere with the subsequent analysis and investigation.

2.2. GC-MS Analysis

The plant oil obtained was subjected to GC/MS analysis [21] at the Centre for Advanced Studies (CAS), Alagappa University, Tamil Nadu. The analysis was performed using a Shimadzu QP-2010 Plus GC-MS system with a Thermal Desorption System TD-20. The system was equipped with an HP-5MS capillary column measuring 30 m × 0.25 mm and a film thickness of 0.25 mm. Helium was used as the carrier gas at a flow rate of 1.0 mL/min, and a split ratio of 1:10 was employed. The temperature program for the GC oven followed a specific protocol. Initially, the oven temperature was set to 50.0 °C and held for 1.00 min. Then, the temperature was increased at 10.00 °C per minute until it reached 280.0 °C. The final temperature was maintained for 5.00 min. Both the injector and detector temperatures were set to 280 °C. Diluted samples (1:10 hexane, v/v) of 0.2 µL were injected for analysis. The mass spectra were obtained using electron ionization (EI) at 70 eV, covering a spectral range from m/z 40 to 700. The identification of the components in the plant oil was performed by evaluating their retention times and indices relative to C5-C28 n-alkanes, conducting computer matching with the WILEY275.L library, and comparing their mass spectra with existing data in the literature.

2.3. Bacterial Strains

The microorganisms used in this study were acquired from the Department of Microbiology at Bharathidasan University in Tamil Nadu, India, including *Escherichia coli*, *Staphylococcus aureus*, *Salmonella* sp., *Campylobacter* sp., *Listeria monocytogenes*, and *Bacillus cereus*. These strains were selected due to their significance as foodborne pathogens and their tendency to develop resistance against various clinical drugs. The streak-plate technique was employed to subculture the pure cultures obtained to ensure the viability of the obtained bacterial cultures. A sterilized cotton swab was used to streak the inoculum onto nutrient agar plates. After inoculation, the Petri dishes were carefully wrapped with parafilm to prevent contamination and ensure uniform bacterial growth. The bacterial cultures were then incubated at a temperature of 37 °C for 24 h, allowing for optimal growth and development of microorganisms.

2.4. Antimicrobial Activity Using Disc Diffusion Method

The antibacterial activity of the plant oils was assessed using the disk diffusion technique. Filter paper discs with a diameter of 5 mm were prepared using Whatman filter paper No. 1. These discs were sterilized at 160 °C for 1 h and then impregnated with the different plant oils used in the study. Following impregnation, the discs were stored at 4 °C. For the susceptibility test against bacteria, Petri plates were prepared by pouring 20 mL of

nutrient agar and allowing it to solidify. A standardized inoculum suspension of 0.1 mL was evenly spread onto the agar surface, and the plates were left to dry for 5 min. The impregnated discs were then gently placed on the surface of the plates using sterile forceps, ensuring adequate contact with the inoculated agar surface. Chloramphenicol was used as an antibiotic control. After this, the inoculated plates were incubated at 37 °C for 24 h. After the incubation period, the zones of inhibition surrounding each disc were carefully observed and measured in millimeters (mm). It is important to note that all the experiments were performed in triplicate to ensure the reliability and accuracy of the results.

2.5. Preparation of Micelle (Working) Solution

The working solutions of the hydrophobic plant oils were prepared according to the protocol outlined by Man et al. [22]. In brief, 2 mL of each pure plant oil was combined with an equal volume of sterile water in 15 mL sterile centrifuge tubes. The mixture was gently and thoroughly mixed overnight at a temperature of 25 °C using an orbital plate mixer. Afterward, the tubes were centrifugated at 5000 rpm for 15 min to ensure a clear separation between the aqueous and nonaqueous phases. Once complete separation was achieved, the bottom homogenous opalescent phase was carefully retrieved and used to determine the minimum inhibitory concentration (MIC) of the plant oils.

2.6. Determination of the Minimum Inhibitory Concentrations (MIC)

The MIC of EOs was determined through broth microdilution according to Clinical and Laboratory Standards Institute (CLSI) guidelines [23] using 96-well plates. Bacterial inocula were prepared by creating bacterial suspensions in saline solution (0.85% NaCl) adjusted to a turbidity equivalent to 0.5 McFarland (2 × 108 colony forming units/µL). The suspensions were adjusted by diluting them in 1:100 sterile Mueller Hinton broth (Himedia, India). Fifty microliters of the diluted bacterial suspension and 50 µL of the EO dilution were added to each 96-well plate, and twofold serial dilutions were performed. The dilutions tested ranged from ~0.25 to ~500 mg/mL. Plates were incubated for 24 h at 37 °C. The MIC value was defined as the lowest concentration at which bacteria showed no growth and was interpreted as the v/v percentage of the stock solution. All tests were performed in triplicate.

2.7. Statistical Analysis

Antibacterial activity was assessed in triplicates with a completely randomized design, and the Zone of Inhibition (ZOI) was expressed as the mean ± standard error. The results were compared using one-way analysis of variance (ANOVA). Statistical significance was considered at $p < 0.05$.

3. Results

The gas chromatography–mass spectrometry (GC-MS) analysis conducted for the chemical profiling of plant oils derived from olive, castor, neem, and coconut showcased an array of compounds, as illustrated in Figure 1. Among the oils, neem oil stood out with the most varied chemical composition, containing a staggering 112 compounds. Within neem oil, 2-ethoxy-4-(4-methyl-1,3-dioxolan-2-yl) phenol made up 2.39%, dehydroabietic acid accounted for 2.2%, hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl)ethyl ester was found at 2.96%, 5-fluoro-2-(4-morpholinyl)-4-pyrimidinamine comprised 3.06%, and 1h-1,3-benzimidazole-2-methanol comprised 1.7%, along with other compounds. Coconut oil also exhibited a rich array, comprising 83 compounds. Some significant components included benzoic acid, 3-formyl-5-methyl-, trimethylsilyl ester at 6.82%, hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester at 5.24%, hexadecanoic acid, n-octyl ester at 4%, 4,8,12,16-octadecatetraen-1-ol, 4,9,13,17-tetramethyl at 2.36%, and dimethylmalonic acid, 4-acetylphenyl undecyl ester at 1.92%. Additionally, olive oil, specifically sourced from India, contained 78 compounds. Among them, phenolic compounds such as octadecanoic acid, 2,3-dihydroxypropyl ester were present at 5.39%, and 2-tetradecynal, 4-hydroxy

at 5.28%. It also had alkaloids like dihydroisoconessimine, accounting for 4.95%, and other constituents like eremophila ketone at 4.01% and cyclohexyl trichloroacetate at 1.55%. Castor oil, which had the fewest compounds among the oils analyzed, comprised 64 compounds. Of these, the phenolic compound 4,4′-isopropylidenebis(2-t-butyl) phenol was found at 1.68%, ketones such as 13-hexyloxacyclotridec-10-en-2-one constituted a significant 30.57%, and 3-hexen-2-one, 3-cyclohexyl-4-ethyl at 7%. additionally, 1,4-benzenedicarboxylic acid, [4-(methoxycarbonyl) phenyl] methyl ester was present at 3.21%, and cyclohexyl methanol, trifluoroacetate (ester) at 3.11%. The complete list of compounds identified from each plant oil is given in the File S1–File S4 (Supplementary Materials).

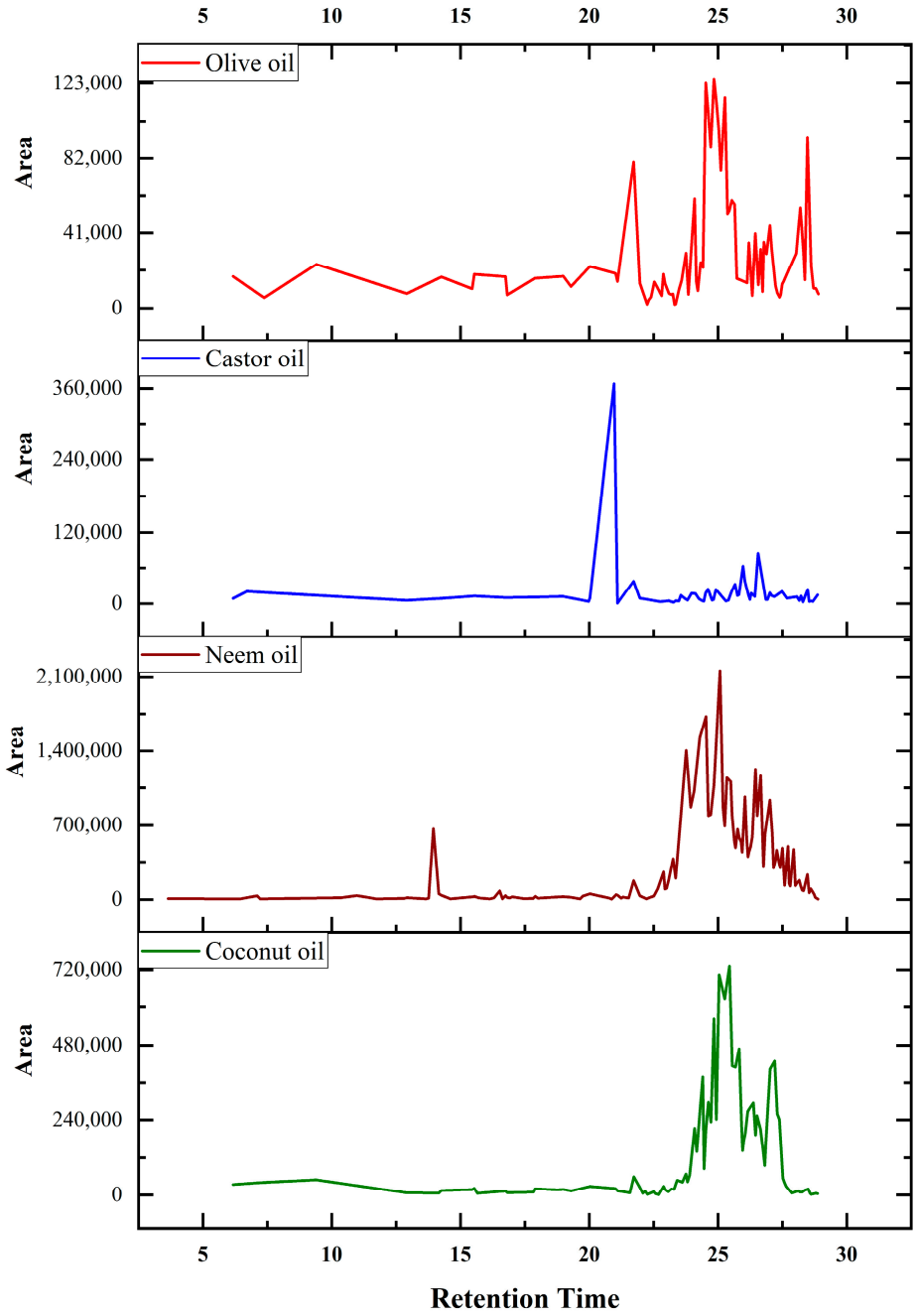

Figure 1. Stacked GC-chromatograms of plant oils (from top to bottom)—olive oil, castor oil, neem oil, and coconut oil. The chromatograms are representations based on data from GC analysis. Actual chromatogram images with peak information and identified compounds can be found in the Supplementary Material Files S1–S4.

Evaluating the antibacterial efficacy of various oils using the disk diffusion method revealed differential zones of inhibition (ZOI) against foodborne pathogens (Table 2). In *Staphylococcus aureus*, neem oil demonstrated a statistically significant reduction in ZOI (13 ± 0.84 mm) as compared to chloramphenicol (20 ± 0.44 mm, $p < 0.05$). In comparison, no significant differences were observed with coconut oil (14 ± 0.55 mm), castor oil (8 ± 0.75 mm), or olive oil. Similarly, for *Bacillus cereus*, neem oil significantly lowered the ZOI (15 ± 0.51 mm) in comparison to the control (20 ± 0.28 mm, $p < 0.05$), while other oils did not exhibit any significant difference. Notably, in *Escherichia coli*, neem oil (15 ± 0.96 mm), coconut oil (10 ± 0.95 mm), and castor oil (8 ± 0.15 mm) each manifested a statistically significant diminution in ZOI relative to the control (20 ± 0.31 mm, $p < 0.05$). Conversely, olive oil (11 ± 0.12 mm) did not differ significantly. In *Salmonella* sp. and *Campylobacter* sp., no oil significantly varied in ZOI relative to the control. For *Listeria monocytogenes*, neem oil (16 ± 0.61 mm), coconut oil (13 ± 1.2 mm), and castor oil (12 ± 1.8 mm) all showed a significant reduction in ZOI when compared with the control (20 ± 0.29 mm, $p < 0.05$), but olive oil (10 ± 0.2 mm) did not. The results revealed neem oil's pronounced antibacterial activity against *Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli*, and *Listeria monocytogenes*, while coconut oil manifested significant activity against *Listeria monocytogenes*.

Table 2. Antibacterial activity of plant oils against foodborne pathogens.

Test Organisms	Zone of Inhibition (ZOI)				
	Control	**Neem Oil**	**Coconut Oil**	**Castor Oil**	**Olive Oil**
Staphylococcus aureus	20 ± 0.44^{a}	13 ± 0.84^{b}	14 ± 0.55^{b}	8 ± 0.75^{c}	ND
Bacillus cereus	20 ± 0.28^{a}	15 ± 0.51^{b}	13 ± 2.6^{c}	11^{c}	11 ± 1.2^{c}
Escherichia coli	20 ± 0.31^{a}	15 ± 0.96^{b}	10 ± 0.95^{c}	8 ± 0.15^{d}	11 ± 0.12^{c}
Salmonella sp.	19 ± 0.25^{a}	13 ± 0.29^{b}	ND	ND	ND
Campylobacter sp.	19 ± 0.12^{a}	14 ± 1.12^{b}	ND	ND	ND
Listeria monoctogenes	20 ± 0.29^{a}	$16 + 0.61^{b}$	13 ± 1.2^{c}	12 ± 1.8^{c}	10 ± 0.2^{d}

ZOI excludes disc diameter. Values are in millimeters (mm). Control—Chloramphenicol. Treatments with different letters are statistically different at a 0.05 significance level.

The minimum inhibitory concentrations (MICs) of the four plant oils were evaluated against various foodborne pathogens (Table 3). Neem oil demonstrated the most potent antimicrobial activity, with MIC values ranging from 1.05 to 6.32 mg/mL against *Staphylococcus aureus*, statistically differing from coconut and castor oils (with values of 8.43 mg/mL and 3.15 mg/mL, respectively). Against *Bacillus cereus*, neem and olive oils both displayed an MIC of 3.15 mg/mL, paralleling each other statistically, but differing from coconut and castor oils, which both recorded 6.32 mg/mL. For *Escherichia coli*, castor oil demonstrated maximum efficacy, with an MIC of 1.05 mg/mL, while neem, coconut, and olive oils were statistically analogous, each displaying an MIC value of 3.15 mg/mL. Coconut oil manifested a marked effect against *Listeria monocytogenes* with an MIC of 3.15 mg/mL, which was statistically divergent from castor oil, which showed a higher MIC of 6.32 mg/mL. Olive oil, with an MIC of 3.15 mg/mL against *Listeria monocytogenes*, was statistically consistent with coconut oil's effect on the same pathogen. Significantly, the control, chloramphenicol, consistently exhibited minimal MIC values (as low as 0.2 mg/mL) across almost all pathogens, indicating its strong antimicrobial efficacy.

Table 3. Minimum inhibitory concentrations (MIC) of different plant oils against foodborne pathogens.

Test Organisms	Neem Oil	Coconut Oil	Castor Oil	Olive Oil	Control
Staphylococcus aureus	1.05 ^{b}	8.43 ^{d}	3.15 ^{c}	ND	0.2 ^{a}
Bacillus cereus	3.15 ^{c}	6.32 ^{b}	6.32 ^{b}	3.15 ^{c}	0.2 ^{a}
Escherichia coli	3.15 ^{b}	3.15 ^{b}	1.05 ^{a}	3.15 ^{b}	0.2 ^{a}
Salmonella sp.	6.32 ^{a}	ND	ND	ND	0.25 ^{a}
Campylobacter sp.	12.65 ^{a}	ND	ND	ND	0.25 ^{a}
Listeria monoctogenes	1.05 ^{a}	3.15 ^{c}	6.32 ^{d}	3.15 ^{c}	0.2 ^{a}

Control—chloramphenicol; all the values are expressed in mg/mL. Treatments with different letters denote statistical significance of the minimum inhibitory concentration (MIC) values.

4. Discussion

Plant oils and extracts have a long history of use in various applications, including food preservation, pharmaceuticals, alternative medicine, and natural therapies. They have been used as traditional treatments for centuries [1]. These oils are widely accessible worldwide and offer promising prospects for discovering novel antimicrobial compounds that are effective against specific bacterial pathogens. This study analyzed four plant oils extracted naturally without adding any chemicals during processing. This approach aimed to avoid any potential interference from preservatives or additives that could affect the antimicrobial activity of the oils. Furthermore, gas chromatography–mass spectrometry (GC-MS) was used to identify the specific compounds in the oils and determine their potential influence on the antibacterial activity against foodborne pathogens.

Neem oil, which exhibited the most varied chemical composition in the current study, has been extensively investigated for its antimicrobial, antiviral, antifungal, and insecticidal properties. The presence of compounds such as 2-ethoxy-4-(4-methyl-1,3-dioxolan-2-yl) phenol, dehydroabietic acid, and hexadecanoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester aligns with previous studies highlighting neem oil's strong antimicrobial activity [24]. Megestrol acetate, identified in neem oil, is known for its anti-inflammatory and anticancer properties [25]. These findings support the extensive use of neem oil in various traditional medicinal practices. Coconut oil, characterized by a significant number of compounds in the current study, has been widely investigated for its potential antimicrobial, antioxidant, and anti-inflammatory activities. The findings also hold promise for the development of more cost-effective and widely accessible treatments, particularly in low-resource settings where access to pharmaceutical-grade antibiotics may be limited. Benzoic acid, 3-formyl-5-methyl-, trimethylsilyl ester, identified in coconut oil, has been reported for its antimicrobial and antifungal effects [26]. The presence of hexadecenoic acid, 2-hydroxy-1-(hydroxymethyl) ethyl ester, aligns with studies highlighting the antioxidant and anti-inflammatory properties of coconut oil [27,28]. These findings reinforce the potential health benefits associated with coconut oil. In the current study, olive oil, particularly olive oil sourced from India, has been extensively studied for its cardioprotective, antioxidant, and anti-inflammatory properties. The presence of phenolic compounds, such as octadecanoic acid, 2,3-dihydroxypropyl ester, and 2-tetradecynal, 4-hydroxy, aligns with previous research highlighting the antioxidant and anti-inflammatory effects of olive oil [29]. Moreover, olive oil's high content of monounsaturated fatty acids, such as oleic acid, has been linked to its cardioprotective effects [30]. These findings support the traditional use of olive oil in promoting cardiovascular health and overall well-being. Castor oil, although having a relatively smaller number of compounds than other oils, has been studied for its potential laxative, anti-inflammatory, and antimicrobial properties. The compound 4,4′-Isopropylidenebis(2-T-butyl) phenol identified in castor oil has been reported for its anti-inflammatory and antioxidant effects [31]. Additionally, the ketone 13-hexyloxacyclotridec-10-en-2-one, found in castor oil, has demonstrated antimicrobial activity against various bacterial strains [32]. These findings support the traditional use of castor oil in promoting digestive health and managing inflammatory conditions. The

identified compounds align with previous studies, highlighting the antimicrobial, antioxidant, anti-inflammatory, and other beneficial effects of these oils. However, it is important to note that further research, including in vitro and in vivo studies, is necessary to fully understand the mechanisms of action and therapeutic potential of these oils and their respective compounds.

The disk diffusion and MIC methods used in this study offer substantial insights into the antibacterial efficacy of neem, coconut, castor, and olive oils against foodborne pathogens. The findings have implications for the potential application of these oils as natural antimicrobial agents. Neem oil stood out with its remarkable antibacterial activity against *Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli*, and *Listeria monocytogenes*, as evidenced by the disk diffusion method. Neem oil's significant activity against *Staphylococcus aureus* is consistent with previous findings [10,24]. The bioactive compounds in neem oil, such as azadirachtin, nimbin, and nimbidin, are thought to be responsible for this effect by disrupting bacterial cell membranes [10]. Moreover, the MIC values for neem oil observed in this study corroborate its potent inhibitory effects, aligning with previous reports where MIC values ranged from 0.25 to 16 mg/mL [10,24]. Coconut oil also exhibited notable antibacterial activity, specifically against *Listeria monocytogenes* (Table 2). This activity is attributed to medium-chain fatty acids, especially lauric acid, in coconut oil [33]. The MIC values for coconut oil were within previously reported ranges (0.2 to 20 mg/mL), further supporting its antibacterial potential [33,34]. In the case of castor oil, moderate antibacterial activity against *Escherichia coli* was observed. The activity of castor oil is believed to be associated with its ricinoleic acid content [35]. The obtained MIC values for castor oil are consistent with earlier findings, which reported MIC values ranging from 0.3 to 64 mg/mL [31,32]. In contrast, olive oil did not exhibit significant antibacterial activity in the disk diffusion assay. While olive oil is recognized for its health benefits due to phenolic compounds such as hydroxytyrosol and oleuropein [23,24], its antimicrobial efficacy can vary depending on the cultivar, geographical origin, and processing methods [33]. The MIC values obtained in this study also reflected olive oil's relatively weaker activity against the tested pathogens, corroborating earlier studies reporting MIC values ranging from 1 to >64 mg/mL [34,35]. Neem and coconut oils showed promising antibacterial activity, while castor oil exhibited moderate activity and olive oil displayed minimal efficacy. The bioactive components present in these oils are likely to contribute to their antimicrobial properties. Further research is warranted to explore the potential of these oils as alternative antimicrobial agents for combating foodborne pathogens.

The findings of this study support the idea that natural plant oils have the potential to be used as alternatives or supplements to conventional antimicrobial agents. However, it is important to acknowledge the limitations of the disk diffusion method, such as variations in oil composition, concentration, and diffusion capacity, which may influence the results. While chloramphenicol was used as a control in this study, further research is needed to investigate these oils' underlying mechanisms of action and potential synergistic effects in combination with other antimicrobial agents. Understanding these aspects would provide valuable insights into their effectiveness and applicability in clinical settings. It is worth noting that the oils examined in this study are commonly used in cooking, and they may naturally exhibit antagonistic effects against foodborne pathogens without causing any side effects associated with other antibiotics. Additionally, using natural oils in food preparation and preservation may help mitigate the concern of antimicrobial resistance, a significant issue in recent years.

5. Conclusions

This study accentuates the potential of neem and coconut oils as potent antimicrobial agents against foodborne pathogens. Neem and coconut oils, owing to their rich bioactive components, have emerged as promising candidates for the development of natural antimicrobial agents. Neem oil exhibited significant antibacterial activity against various Gram-positive and Gram-Negative bacteria, particularly against *Staphylococcus aureus* and

Bacillus cereus. Coconut oil showed notable activity against *Listeria monocytogenes*. Castor oil displayed moderate activity, while olive oil, which is a carrier oil, exhibited minimal antibacterial effects. The GC-MS analysis revealed a diverse array of compounds in neem oil, which likely contributes to its potent antibacterial properties. By harnessing their inherent antimicrobial properties, it may be possible to enhance their use for the fight against antimicrobial resistance and other applications like food safety and shelf life while simultaneously reducing reliance on synthetic preservatives.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/microbiolres14030087/s1. The complete list of compounds identified from each plant oil. File S1: Castor Oil; File S2: Coconut Oil; File S3: Neen Oil; File S4: Olive Oil.

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