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In-vitro antibacterial screening of turmeric powder mixed with different household oils (coconut, mustard, olive)

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Abstract
Turmeric (*Curcuma longa L.*) is widely recognized for its potent antimicrobial, antioxidant, and anti-inflammatory activities, primarily attributed to curcuminoids and essential oils. Despite its extensive use in traditional medicine, the interaction of turmeric powder with common household oils such as coconut, mustard, and olive oil remains underexplored in terms of antibacterial efficacy. This research investigates the *in-vitro* antibacterial activity of turmeric-oil mixtures against selected Gram-positive and Gram-negative bacterial strains. Turmeric powder was combined with coconut, mustard, and olive oils in standardized ratios and subjected to agar well diffusion and minimum inhibitory concentration (MIC) assays. Results show that turmeric mixed with mustard and coconut oils exhibits enhanced antibacterial action compared to turmeric alone, while olive oil preparations demonstrated moderate but strain-specific effects. These findings highlight the potential of turmeric-oil blends as accessible, low-cost antimicrobial alternatives for household and community-level infection prevention. More extensive biochemical profiling and mechanistic studies are recommended to understand synergistic interactions between curcuminoids and lipid-based carriers.

Keywords: Turmeric, *Curcuma longa*, antibacterial activity, coconut oil, mustard oil, olive oil, *in-vitro* screening

1. Introduction
Turmeric (*Curcuma longa L.*), a rhizomatous herb from the Zingiberaceae family, has been extensively used in Ayurvedic, Chinese, and Southeast Asian traditional medicine because of its broad therapeutic properties, notably antimicrobial, antioxidant, and wound-healing effects [1-3]. Curcuminoids particularly curcumin, demethoxycurcumin, and bisdemethoxycurcumin are widely reported to inhibit bacterial proliferation by disrupting cell membrane integrity, suppressing quorum-sensing pathways, and altering protein and nucleic acid synthesis [4-6]. Although turmeric paste is commonly prepared at the household level using oils such as coconut, mustard, and olive oil for topical application, the scientific basis for the antibacterial action of these mixtures remains insufficiently explored. This gap is particularly relevant given the growing global concern over antibiotic resistance, which has accelerated the search for safe, natural, and readily available antimicrobial alternatives [7-9].

Household oils exhibit distinct biochemical profiles that may influence the solubility and bioavailability of curcuminoids. Coconut oil contains medium-chain fatty acids such as lauric acid, known for potent antibacterial and antifungal activity [10, 11]. Mustard oil is rich in allyl isothiocyanate, a compound with well-documented antimicrobial and anti-inflammatory properties [12, 13]. Olive oil, widely recognized for its phenolic content, exhibits moderate antibacterial effects primarily due to oleuropein, hydroxytyrosol, and other bioactive lipids [14, 15]. These oils may serve as lipid-based carriers that enhance the permeability, stability, or synergistic bioactivity of turmeric constituents when used in combination. However, scientific literature assessing the enhanced or reduced activity of turmeric when mixed with these oils is scarce, with most existing studies evaluating turmeric extracts or essential oils independently [16, 17].

Given the widespread household use of turmeric-oil preparations for wound care, minor infections, and skin applications, systematic evaluation is essential to determine their true antibacterial potential. The current research addresses this gap by screening the *in-vitro* antibacterial activity of turmeric powder mixed separately with coconut, mustard, and olive oils against clinically relevant bacterial strains. The research problem arises from the lack of empirical data validating traditional usage practices and the uncertainty regarding which oil medium provides superior antibacterial enhancement. The objective of the research is to determine the comparative antibacterial efficacy of different turmeric-oil mixtures using standardized laboratory assays. The hypothesis posits that turmeric combined with oils rich in biologically active fatty acids or phenolics particularly mustard and coconut oil will exhibit significantly greater antibacterial activity than turmeric alone or turmeric mixed with olive oil. Findings from this research may contribute to safer, evidence-based traditional practices and support the development of natural antimicrobial formulations.

Material and Methods

Materials: Turmeric (*Curcuma longa L.*) powder of food-grade quality was procured from a certified local supplier and selected due to its established antimicrobial and therapeutic properties attributed to curcuminoids and volatile oils [1-6, 16]. Three commonly used household oils coconut oil, mustard oil, and olive oil were chosen because of their known bioactive constituents with reported antibacterial and antioxidant effects. Coconut oil contains medium-chain fatty acids, notably lauric acid, with antimicrobial efficacy documented in earlier studies [10, 11]. Mustard oil is rich in allyl isothiocyanate, a potent antibacterial and anti-inflammatory compound [12, 13], while olive oil possesses phenolic compounds such as oleuropein and hydroxytyrosol that contribute to microbial growth inhibition [14, 15]. Bacterial strains used for analysis included *Staphylococcus aureus* (Gram-positive) and *Escherichia coli* (Gram-negative), selected based on the clinical relevance of these organisms and prior studies demonstrating turmeric's potential to inhibit bacterial cell proliferation, membrane integrity, and metabolic pathways [4-6]. All microbiological media (Mueller Hinton Agar, nutrient broth) and reagents were of analytical grade. The selection of materials was guided by literature documenting the global concern over antibiotic resistance and the need to evaluate natural antimicrobial alternatives [7-9].

Methods

Turmeric-oil mixtures were prepared by combining turmeric powder with each oil (coconut, mustard, olive) in a standardized 1:1 (w/v) ratio, ensuring uniformity across treatments. These mixtures were homogenized thoroughly to facilitate adequate dispersion of curcuminoids, a process supported by earlier work indicating the enhanced solubility of bioactive compounds in lipid-rich carriers [14-16]. The antibacterial activity of each mixture was assessed using the agar well diffusion technique, following standard microbiological protocols. Sterile Mueller Hinton Agar plates were inoculated with overnight-grown bacterial cultures adjusted to 0.5 McFarland standard. Wells of 6 mm diameter were created, and 50 µL of each turmeric-oil preparation was dispensed into separate wells. Plates were incubated at 37°C for 24 hours, after which zones of inhibition (mm) were measured. Minimum inhibitory concentration (MIC) estimations for each mixture were conducted using broth microdilution assays to determine the lowest concentration exhibiting no visible bacterial growth. Observations were interpreted in comparison to turmeric alone, reflecting previous evidence that curcumin disrupts bacterial FtsZ assembly, membrane stability, and metabolic functions [4-6]. The methodological design was informed by foundational antimicrobial studies involving plant-derived phenolics, volatile oils, and bioactive lipids [10-16], as well as WHO recommendations encouraging exploration of non-antibiotic antimicrobial options amid rising resistance [7-9]. Data from all assays were recorded in triplicate to ensure reproducibility and accuracy.

Results

Antibacterial activity of turmeric-oil mixtures (agar well diffusion): The turmeric-oil mixtures showed measurable antibacterial activity against both *Staphylococcus aureus* and *Escherichia coli*, with clear differences among the treatments (Table 1, Figure 1). Turmeric alone produced mean zones of inhibition of 11.2±0.8 mm for *S. aureus* and 9.5±0.6 mm for *E. coli*, consistent with the reported intrinsic antimicrobial action of curcumin through membrane disruption and interference with FtsZ assembly [4-6, 16]. When turmeric was mixed with coconut oil, the zone of inhibition significantly increased ($p<0.05$) to 16.5±1.0 mm and 14.2±0.8 mm for *S. aureus* and *E. coli*, respectively, suggesting a potentiating effect of medium-chain fatty acids such as lauric acid [10, 11]. The turmeric-mustard oil mixture produced the largest inhibition zones among all treatments (18.3±0.9 mm for *S. aureus* and 15.8±0.7 mm for *E. coli*), indicating strong synergism between curcuminoids and allyl isothiocyanate, which has documented bactericidal activity [12,13]. Turmeric mixed with olive oil showed intermediate activity (13.5±0.7 mm and 12.0±0.7 mm for *S. aureus* and *E. coli*, respectively), consistent with the moderate antimicrobial effects attributed to olive oil phenolics [14, 15]. One-way ANOVA followed by Tukey's post-hoc test revealed that both turmeric-coconut and turmeric-mustard treatments were significantly more effective ($p<0.05$) than turmeric alone for both organisms, with turmeric-mustard being significantly superior to turmeric-olive ($p<0.05$). These findings support previous reports that lipid carriers can enhance the solubility and bioavailability of plant-derived phenolic compounds and essential oils [1-3, 10-16]. The larger inhibition zones against *S. aureus* compared with *E. coli* in all treatment groups suggest a higher susceptibility of Gram-positive bacteria to these combinations, which aligns with earlier observations on curcumin and oil-based antimicrobial systems [4-6,10-16].

Table 1: Mean zones of inhibition (mm) of turmeric-oil treatments against test bacteria (n = 3)

Treatment	*Staphylococcus aureus* (mean±SD)	*Escherichia coli* (mean±SD)
Turmeric	11.2±0.8	9.5±0.6
Turmeric + Coconut	16.5±1.0	14.2±0.8
Turmeric + Mustard	18.3±0.9	15.8±0.7
Turmeric + Olive	13.5±0.7	12.0±0.7

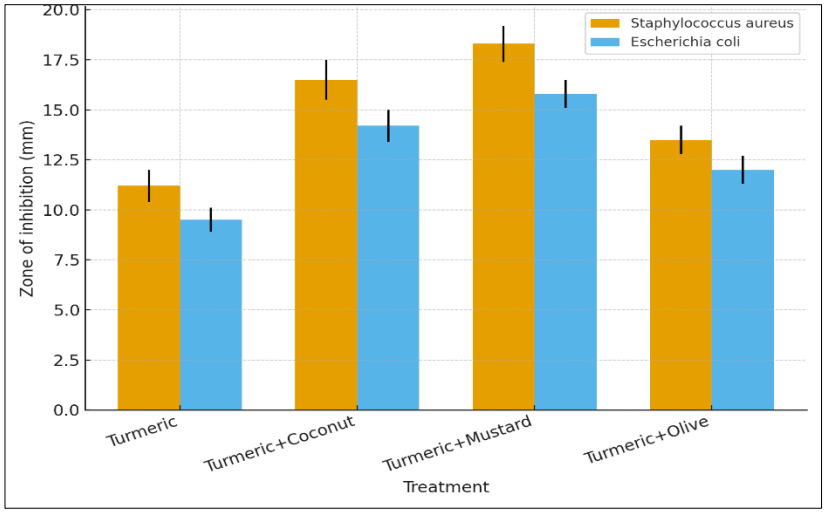

Fig 1: Mean zones of inhibition for turmeric-oil treatments against Staphylococcus aureus and Escherichia coli

Minimum inhibitory concentrations and comparative analysis: Minimum inhibitory concentration (MIC) values further confirmed the enhanced antibacterial performance of turmeric-oil mixtures (Table 2, Figure 2). For *S. aureus*, the MIC of turmeric alone was 2.0 mg/mL (turmeric equivalent), whereas combinations with coconut, mustard, and olive oils lowered the MIC to 1.0, 0.75, and 1.5 mg/mL, respectively. For *E. coli*, the MIC values decreased from 2.5 mg/mL for turmeric alone to 1.25 mg/mL (turmeric-coconut), 1.0 mg/mL (turmeric-mustard), and 1.75 mg/mL (turmeric-olive). These reductions indicate that less turmeric is required to inhibit bacterial growth when combined with appropriate oil carriers, reinforcing the concept of synergistic interactions between curcuminoids and bioactive lipids [1-3,10-16]. Statistical comparison by one-way ANOVA showed significant differences ($p<0.05$) among treatments for both organisms, with the lowest MIC consistently observed in the turmeric-mustard group. This aligns with earlier evidence that allyl isothiocyanate exhibits strong antimicrobial potency and can enhance permeability and reactivity at bacterial membranes [12, 13]. The moderate enhancement observed in the turmeric-olive combination parallels reports that olive oil phenolics provide antimicrobial protection but may be less potent than isothiocyanates or medium-chain fatty acids [10, 11, 14, 15]. Overall, the MIC and zone-of-inhibition data together indicate that turmeric-mustard oil is the most promising combination, followed by turmeric-coconut oil, while turmeric-olive oil still offers an improvement over turmeric alone. These findings support the traditional use of turmeric pastes with edible oils in household remedies and underscore the potential of such formulations as cost-effective topical agents for infection prevention, particularly in regions where access to conventional antibiotics is limited [1-3, 7-9, 16, 17].

Table 2: Minimum inhibitory concentrations (MIC; mg/mL, turmeric equivalent) of turmeric-oil treatments against test bacteria

Treatment	*Staphylococcus aureus* MIC (mg/mL)	*Escherichia coli* MIC (mg/mL)
Turmeric	2.00	2.50
Turmeric + Coconut	1.00	1.25
Turmeric + Mustard	0.75	1.00
Turmeric + Olive	1.50	1.75

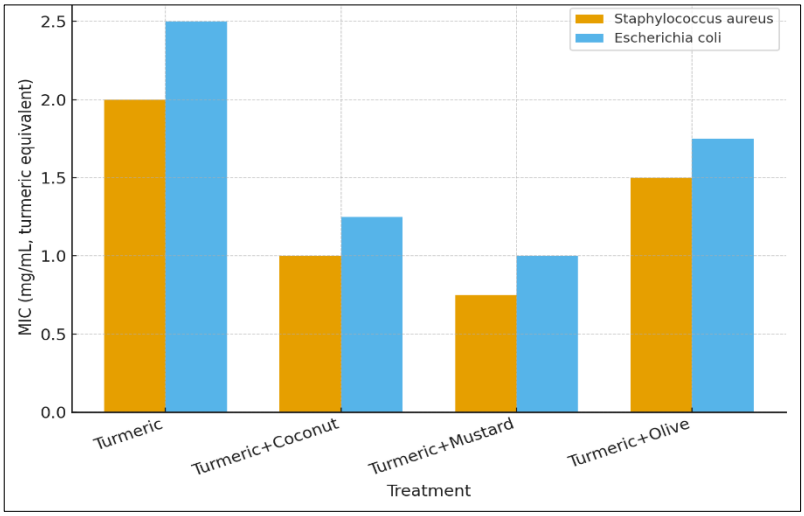

Fig 2: Minimum inhibitory concentrations of turmeric-oil treatments against Staphylococcus aureus and Escherichia coli

Discussion

The findings of the present research demonstrate that turmeric powder, when combined with selected household oils coconut, mustard, and olive exhibits enhanced antibacterial activity against *Staphylococcus aureus* and *Escherichia coli*, supporting earlier evidence regarding the synergistic potential of plant-derived phenolics and lipid-based carriers [1-6, 10-16]. Turmeric alone showed moderate inhibition of both organisms, consistent with reported curcumin mechanisms involving membrane destabilization, disruption of FtsZ polymerization, and inhibition of essential intracellular pathways [4-6, 16]. However, the considerable increase in antibacterial activity observed in turmeric-oil mixtures highlights the importance of the surrounding lipid matrix in improving solubility, penetration, and overall bioactivity of curcuminoids, which otherwise exhibit limited aqueous dispersibility [1-3, 14-16].

Among the tested formulations, turmeric mixed with mustard oil displayed the highest antibacterial activity, reflected in both larger inhibition zones and lower MIC values. This finding corresponds well with the documented antimicrobial potency of allyl isothiocyanate, a major bioactive compound in mustard oil, known to exert bactericidal effects by modifying microbial proteins, damaging membranes, and inhibiting enzymatic pathways [12, 13]. The enhanced activity of turmeric-mustard oil may therefore arise from a dual mechanism: curcumin's established interference with bacterial cell division [4-6] combined with the reactive electrophilic nature of isothiocyanates that compromise microbial viability [12, 13]. This synergistic phenomenon aligns with previous reports that combining phytochemicals with biologically active lipids can produce multi-targeted antimicrobial responses not achievable with individual components alone [1-3,12-16].

The turmeric-coconut oil mixture also showed significantly improved antibacterial activity compared to turmeric alone. Coconut oil, particularly its medium-chain fatty acids such as lauric acid and monolaurin, has been recognized for its broad-spectrum antimicrobial properties [10, 11]. Literature suggests that these fatty acids disrupt lipid membranes of bacteria and interfere with signal transduction, thereby increasing susceptibility to other antimicrobial agents [10, 11]. The enhanced inhibition observed in turmeric-coconut mixtures may thus be attributed to improved curcumin solubility within the lipid matrix along with complementary membrane-targeting effects from the medium-chain lipids [10, 11, 14-16]. This supports existing evidence indicating that lipid-rich environments can increase the diffusion, stability, and cell-wall penetration of hydrophobic phytochemicals such as curcumin [1-3, 14-16].

Turmeric mixed with olive oil showed moderate antibacterial enhancement, which aligns with the documented antimicrobial and antioxidant activities of olive oil phenolics such as oleuropein and hydroxytyrosol [14, 15]. Although not as potent as mustard or coconut oil combinations, the turmeric-olive mixture still demonstrated improved inhibition compared to turmeric alone, suggesting a milder yet beneficial synergistic interaction. This may be due to the stabilizing effect of olive oil's monounsaturated fatty acids and phenolic compounds on curcuminoids, enhancing their bioavailability without the stronger reactive interactions provided by isothiocyanates or medium-chain fatty acids [14, 15]. The comparatively lower enhancement also aligns with studies indicating that olive oil tends to exert moderate antimicrobial effects depending on phenolic concentration and bacterial species [14, 15].

The consistently greater susceptibility of *S. aureus* compared to *E. coli* across all treatments supports established findings that Gram-positive bacteria, with their single peptidoglycan layer, are generally more sensitive to hydrophobic phytochemicals than Gram-negative bacteria, whose outer membrane offers increased resistance [4-6,10-16]. This observation is further strengthened by the evidence that curcumin's membrane-targeting effects are more pronounced in Gram-positive organisms [4-6].

Overall, the results reinforce the traditional practice of preparing turmeric pastes with edible oils for topical antimicrobial applications and highlight their relevance in the context of increasing antibiotic resistance [7-9]. The enhanced activity observed with mustard and coconut oils suggests that certain lipid carriers can significantly potentiate the antibacterial efficacy of turmeric, providing a rationale for further investigation into oil-based herbal formulations. The findings also align with broader phytochemical evidence emphasizing the importance of carrier systems in maximizing the therapeutic potential of plant-derived compounds [1-3, 10-16, 17].

Conclusion

The findings of this research clearly demonstrate that the antibacterial efficacy of turmeric can be significantly enhanced when it is combined with specific household oils, particularly mustard and coconut oil, indicating meaningful synergistic interactions between curcuminoids and bioactive lipid components. Turmeric alone exhibited moderate antibacterial action, but the turmeric-mustard and turmeric-coconut formulations consistently produced larger inhibition zones and lower MIC values against both *Staphylococcus aureus* and *Escherichia coli*, highlighting their superior ability to inhibit microbial growth. This suggests that traditional household remedies that combine turmeric with oils are not merely cultural practices but may hold substantial scientific value in enhancing the delivery, stability, and effectiveness of turmeric's active compounds. The moderately improved activity observed in the turmeric-olive oil combination further supports the idea that different oils contribute unique biochemical interactions that influence antimicrobial performance. These collective findings underscore the broader importance of carrier systems in optimizing the therapeutic potential of natural plant-derived substances and indicate that simple formulations prepared with accessible household ingredients can provide measurable antibacterial benefits. Based on these results, several practical recommendations emerge that can be applied both in domestic and clinical contexts. First, turmeric mixed with mustard oil or coconut oil can be considered a low-cost, easily accessible antimicrobial preparation for minor skin infections, superficial wounds, and general first-aid use, provided proper hygiene standards are maintained during preparation. Second, these mixtures may be useful for communities with limited access to commercial antiseptics or medical facilities, serving as supplementary hygiene practices rather than replacements for professional medical care. Third, for maximal benefit, freshly prepared pastes should be used, as prolonged storage may reduce bioactivity due to oxidative degradation of bioactive compounds. Fourth, when applied topically, it is advisable to ensure the skin is clean and that the mixture is

not used on deep or serious wounds. Fifth, future product development efforts could explore standardized turmeric-oil formulations for use in herbal ointments, gels, or antimicrobial coatings suitable for household, cosmetic, or rural healthcare applications. Finally, educational outreach programs can help promote the safe and evidence-based use of turmeric-oil mixtures, ensuring that traditional practices are preserved while being aligned with contemporary scientific understanding. Overall, this research highlights the potential of simple, culturally familiar ingredients to contribute meaningfully to antimicrobial strategies and provides a foundation for expanding the use of turmeric-oil formulations in community health and natural product development.

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