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Article

The growth of bacteria on everyday objects and the antimicrobial effects of household spices

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SUMMARY

Bacteria are found on everyday objects, where they survive for days to weeks, potentially affecting human health. However, our understanding of bacterial resilience and its interaction with everyday surfaces is limited. This study explored the antimicrobial properties of household spices against bacteria obtained from commonly used, everyday objects. We hypothesized that among select items (cellphone, door handle, computer touchpad, and stair handle), certain surfaces, such as the door handle and computer touchpad, would allow for greater net bacterial growth than others, and that household spices (honey, chili powder, turmeric, and sumac) would inhibit bacterial growth at different rates. We conducted two independent experiments. The first experiment evaluated the effect of honey and chili powder on the growth of bacteria isolated from a cellphone screen and a door handle. The second experiment examined how turmeric and sumac impacted the growth of bacteria isolated from a stair handle and a computer touchpad. The results showed that the bacteria collected from the door and stair handles grew faster than those from the cellphone screen and computer touchpad surfaces. While all spices exhibited inhibitory effects compared to the no-treatment conditions, chili powder and turmeric revealed stronger inhibitory effects compared to honey and sumac. These findings indicate that household spices offer protective antibacterial properties. These household spices could represent promising natural and readily available alternatives to chemical disinfectants.

INTRODUCTION

Bacteria live on surfaces for days to weeks and are among the fastest reproducing organisms in the world, with certain types of bacteria doubling every 4 to 20 minutes (1, 2). Everyday items and surfaces such as stair handles, computers, and touchpads are hotspots for bacterial growth due to frequent handling, leading to the transfer and accumulation of microorganisms from human skin. This constant exchange contributes to the bacterial load on these surfaces, posing a potential risk of spreading harmful pathogens (1, 3). Research has found that computer mice and mouse pads harbor harmful bacteria, such as *Escherichia coli (E. coli*), due to constant exposure to food remnants and moisture, and regular use by multiple individuals (4). Furthermore, research has shown that a cellphone screen can carry multiple types of pathogenic microbes, containing over 25,000 bacteria per square inch (5-7). Door handles provide another commonly used surface where bacteria transfer between people, with up to 60% of workplace individuals acquiring from doorknobs they touch (8, 9). Nonetheless, these are surfaces that we tend to forget can contain harmful microorganisms (1, 3).

Historically, people have used spices to treat wounds, clean surfaces, and prevent diseases (10). A recent study compared the antibacterial properties of household spices (cinnamon, cumin, nutmeg, and ground white pepper) to toothpaste and found cinnamon to be the most effective spice in inhibiting bacterial growth (11). Similarly, people have long used honey and chili powder in Asia for their potential antibacterial effects. In fact, people have used honey since ancient times to rapidly heal wounds and alleviate sickness (12, 13). Chili peppers contain capsaicinoids, which have dose-dependent anti-inflammatory properties similar to anti-inflammatory drugs (14). Powdered chili is commonly used in food and other purposes in Asia. Sumac and turmeric are not just culinary staples but also potent sources of phytochemicals—protective plant-based bioactive compounds. These compounds offer a range of health benefits, including combating infections through their anti-inflammatory and antioxidant properties (15). However, researchers have not directly compared the antibacterial effects of these four household ingredients (chili powder, turmeric, sumac, and honey).

This study tested whether these spices could serve as viable alternatives or complements to traditional synthetic disinfectants. This study had two goals: (i) to investigate which everyday surfaces allow the greatest net bacterial growth (stair handle, computer touch pad, door handle, and cellphone screen); (ii) to determine which household spices inhibit the growth of bacteria more effectively. We hypothesized that bacteria isolated from a cellphone screen and a computer touchpad would have the highest growth and that chili powder and turmeric would inhibit bacterial growth the most. We cultured bacteria from the surfaces of the cellphone screen, door handle, stair handle, and computer touchpad, and added spices (honey powder, chili powder, turmeric, and sumac) to see how they affected the net bacterial growth, defined as the overall increase of the bacterial population over the study period. This study featured two independent, student-led investigations, and the results should be interpreted as two separate experiments. We found greater net bacterial growth from door handles compared to the cellphone screen. We also saw that chili powder and turmeric reduced bacterial growth more than honey powder and sumac.

Our findings support the claim that commonly used household spices can serve as natural antibacterial agents. With rising concerns about antibiotic resistance and the

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environmental impact of synthetic disinfectants, natural alternatives could offer a more sustainable option for everyday sanitation. Our research bridges a gap between traditional knowledge and modern science and informs future low-cost public health strategies and sanitation practices. By demonstrating that certain spices can significantly slow bacterial growth on common surfaces, we provide a practical and affordable way for individuals to reduce germ transmission in their daily lives, particularly in highly frequented environments like homes, offices, and public transit.

RESULTS

We compared the net bacterial growth from samples collected from four common surfaces: door handle, cellphone screen, stair handle, and computer touchpad. After swabbing these surfaces with sterile cotton applicators, we cultured the bacteria on agar plates supplemented with various household spices (**Tables 1 and 2**). We used sterile water as a negative control and monitored bacterial growth daily for five days at room temperature (**Figure 1**).

Effect of chili powder and honey powder on net bacterial growth from door handle and cellphone screen samples

We examined the turbidity of the liquid cultures through an optical density (OD_{600}) reading after two days of culture to estimate the initial bacterial presence. Bacteria collected from the door handle and cell phone screen had optical densities (OD_{600}) of 0.46 and 0.12, respectively. The negative control showed no visible turbidity, suggesting no contamination. Since we did not control for optimal culture conditions and differential growth rates, we could not make assertions on the bacterial concentration differences between the door handle

Treatments	Total plates	Distribution of Plates	Preparation
Chili powder	6 plates (20 mL/plate)	Door handle (n = 3) Cellphone Surface (n = 3)	150 mL of agar + 7.5 g of chili powder
Honey power	6 plates (20 mL/plate)	Door handle (n = 3) Cellphone Surface (n = 3)	150 mL of agar +7.5 g of honey powder
Control	9 plates (20 mL/plate)	Door handle (n = 3) Cell Phone Surface (n = 3) Negative Control (n = 3)	150 mL of agar

Table 1. Bacterial testing plate preparation for chili powder and honey powder treatment. Chili powder-treated agar plates and honey powder-treated agar plates are prepared by mixing agar with 7.5 g of the respective household spice. The agar is poured into a petri-dish and left to cool at room temperature. Each treatment includes plates with three replicates (n = 3) swabbed with bacteria from the door handle and cell phone, and negative control (sterile water).

Treatments	Total plates	Distribution of plates	Preparation
Sumac	3 plates (20 mL/plate)	Computer Touch Pad (n = 3)	150 mL of agar + 7.5 g of Sumac
Turmeric	3 plates (20 mL/plate)	Stair Handle (n = 3)	150 mL of agar +7.5 g of Turmeric
Control	5 plates (20 mL/plate)	Computer Touch Pad (n = 2) Stair Handle (n = 2) Negative Control (n = 1)	150 mL of agar

Table 2. Bacterial testing plate preparation for sumac and turmeric treatment. Sumac and turmeric-treated agar plates are prepared by mixing agar with 7.5 g of the respective household spice. The agar is poured into a petri dish and left to cool at room temperature. Each treatment includes plates swabbed with bacteria from the stair handle and computer touch pad, and a negative control (sterile water). Conditions varied in replicate counts (sumac and turmeric, n = 3; computer touch pad and stair handle controls, n = 2; negative control, n = 1).

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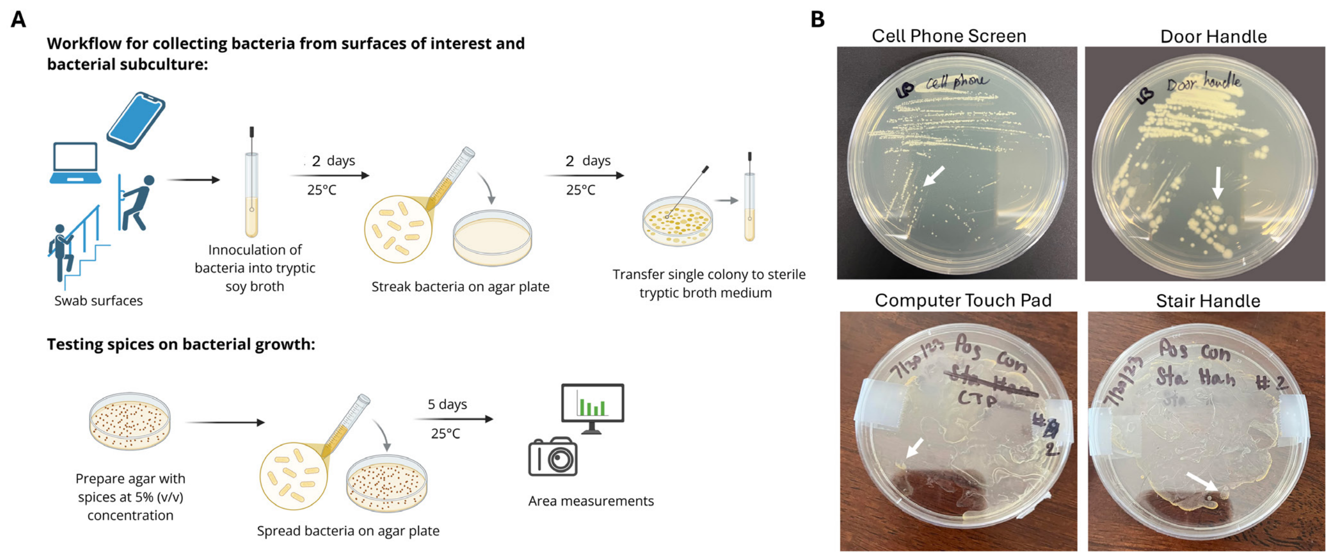

Figure 1. Experimental steps and representative pictures of streaked bacterial culture in agar plates. (A) Bacteria were collected from everyday surfaces (cellphone screen, door handle, computer touchpad, and stair handle) and then grown in Tryptic Soy Broth (TSB) medium for 2 days. To ensure a homogenous population, a single colony from each liquid culture was subcultured on Luria-Bertani (LB) agar, then regrown in fresh TSB. LB agar plates containing either no spice (control) or a 4% concentration of the test spice (turmeric, sumac, chili powder, honey powder) were prepared, and liquid bacterial culture was spread onto each plate. Plates were incubated at room temperature for 5 days, and daily images were obtained to monitor and quantify the percentage of plant coverage. Created in BioRender (22). (B) Representative images of bacteria cultured in agar plates. Single colonies (arrows) were collected for follow-up experiments.

and cellphone screen swabs. We then streaked the liquid cultures in agar plates to select a colony for further subculture in liquid culture.

Once the single colony liquid culture was streaked onto agar plates, we observed distinct population patterns developing from day 1 (**Figure 2A**) to day 5 (**Figure 2B**). Colonies from the cellphone screen sample appeared smaller than those from the door handle after five days of culture (**Figure 2B**, Cellphone screen – bottom row – and Door handle – top row).

For the door handle-derived bacteria, on control (no-spice) agar plates (**Table 1**, n = 3), bacterial coverage reached 16% on Day 1 and nearly 100% by Day 2 (**Figure 2C**). Plates containing honey powder (**Table 1**, n = 3) exhibited 0% coverage on Day 1, 35% on Day 2, and achieved 100% coverage by Day 3. In contrast, the chili powder-treated agar plates (**Table 1**, n = 3) showed 0% coverage on Day 1, only 7% on Day 2, 72% on Day 3, and approached full coverage by Day 4, demonstrating the slowest net bacterial growth among the treatment conditions (**Figure 2C**). We found a statistically significant difference in bacterial growth among the spice treatments for bacteria collected from the door handle (p = 0.02, n = 3).

For the cellphone screen-derived bacteria, plates without added spices (**Table 1**, n = 3) showed no visible colony formation from Days 1 through 4 but reached 13% coverage by Day 5 (**Figure 2D**). Plates containing honey powder (**Table 1**, n = 3) similarly showed no growth until Day 5, when they reached 12% coverage. Chili powder-treated plates (**Table 1**, n = 3) remained at 0% coverage through Day 4 and reached only 6% by Day 5 (**Figure 2D**). However, we observed no statistically significant differences in bacterial growth among treatments in this group.

Effect of turmeric and sumac on net bacterial growth from stair handle and computer touchpad samples

Prior to plating, liquid cultures derived from the stair handle and computer touchpad appeared turbid, while the negative control tube containing only sterile water showed slight turbidity, which may indicate minimal environmental contamination.

After we streaked the bacterial samples onto agar plates (**Figure 3A**), both the stair handle and computer touchpad samples displayed distinct bacterial morphologies after five days of incubation (**Figure 3B**). Agar plates containing turmeric or sumac (**Table 2**, n = 3) reduced bacterial growth compared to those without added spices (**Table 2**, variable n), with turmeric resulting in slightly less bacterial coverage than sumac (**Figure 3B**).

For the stair handle, the control (no-spice) agar plate (**Table 2**, n = 2) showed rapid growth, with plate coverage reaching approximately 78% by Day 2 and stabilizing around 80% by Day 5 (**Figure 3C**). Bacteria grown on turmeric-supplemented agar (**Table 2**, n = 3) demonstrated a noticeably reduced expansion, remaining under 50% plate coverage by Day 5 (**Figure 3C**).

In the computer touchpad samples, control plates (**Table 2**, n = 2) reached approximately 80% coverage by Day 3. Sumac-treated plates (**Table 2**, n = 3) exhibited slower expansion and remained under 60% coverage throughout the five days (**Figure 3D**). These findings revealed statistically significant differences in bacterial growth for both surface types across the treatment conditions (p = 0.012 for turmeric, p = 0.013 for sumac). These results suggest that both turmeric and sumac inhibited bacterial growth compared to the control condition, with turmeric demonstrating slightly stronger effects.

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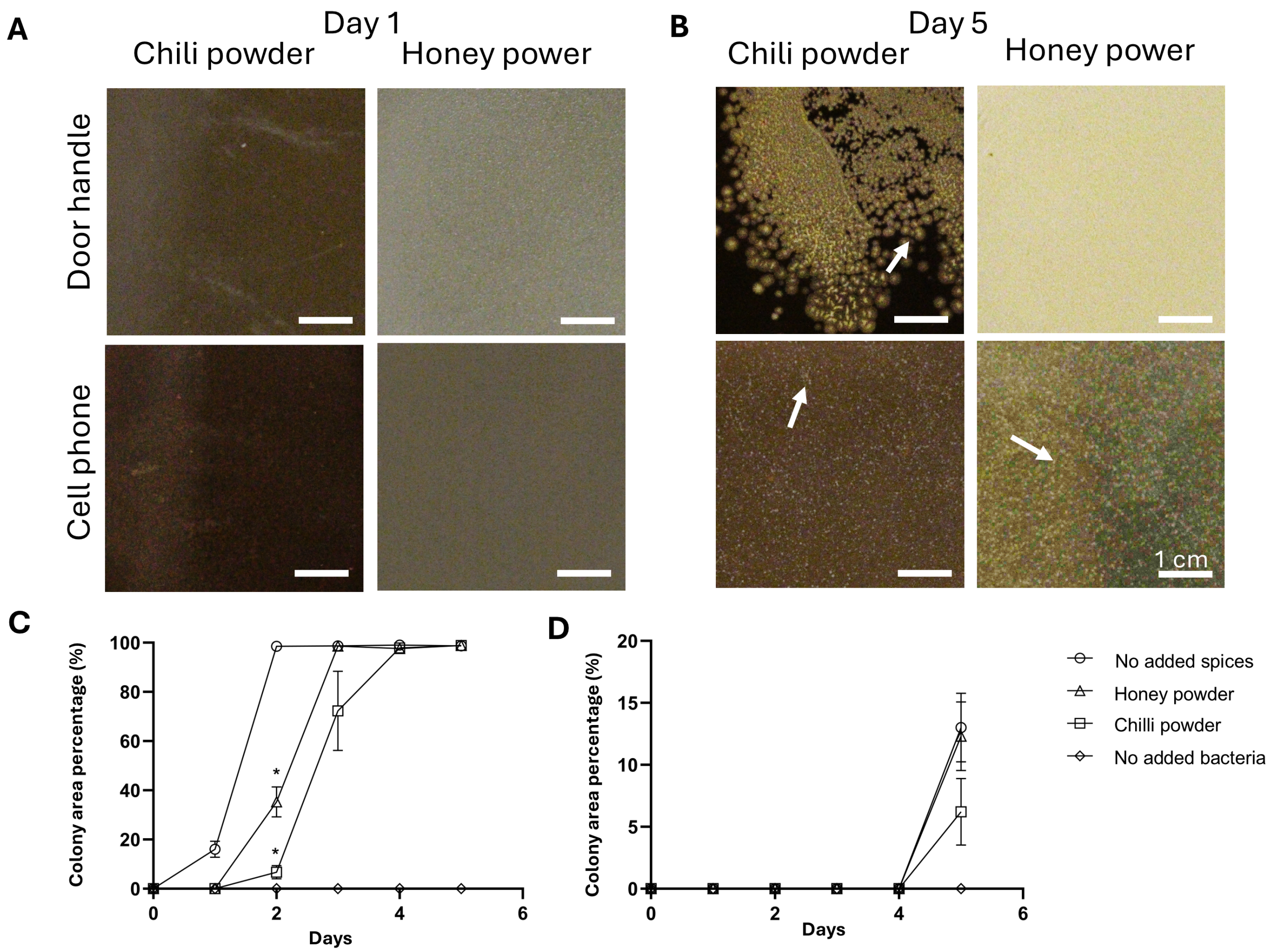

Figure 2. Effect of chili and honey powder treatments on bacteria collected from a door handle and a cellphone over time. (A, B) Bacteria were grown under control conditions, on chili powder-treated agar plates, or honey powder-treated agar plates over a period of 5 days (scale bar = 1 cm). Representative images of plates at (A) day 1 and (B) day 5. Bacterial growth can be seen as indicated by white arrows. The lighter background of honey-treated plates reduces visual identification of bacterial colonies. Line graph showing the average detected colony area percentage of bacteria on agar plates collected from (C) the door handle and (D) the cellphone screen. Plate coverage was quantified using ImageJ. Error bars represent standard deviation. One-way ANOVA test revealed statistical significance in differences in bacterial growth among different spice treatments for bacteria collected from a door handle (*$p < 0.05$, n = 3), but no significance for bacteria collected from the cell phone screen.

DISCUSSION

In this study, we investigated the antimicrobial potential of turmeric, sumac, honey powder, and chili powder on bacteria collected from everyday surfaces such as stair handles, computer touchpads, door handles, and cellphone screens. Our results suggest that these household spices exhibit antibacterial properties, as spice-treated surfaces consistently showed reduced net bacterial growth compared to surfaces without treatment. In particular, chili powder and turmeric appeared to be the most effective, with treated agar plates showing less than 50% plate coverage as compared to untreated samples. These findings support our hypothesis that turmeric and chili powder can inhibit bacterial growth under our tested conditions and may serve as potential natural alternatives to synthetic disinfectants.

Previous studies show that sumac, especially in the form of essential oils and extracts, exhibits antibacterial effects against pathogenic microbes (16). In our study, we observed that bacteria collected from the door handle and cellphone screen responded differently to spice treatments. Bacteria sampled from the cellphone screen showed slower net growth and smaller colony coverage overall. However, since we did not analyze bacterial species collected from each surface, it is also possible that the cellphone screen tested harbored different bacterial types or species. Future research could investigate which bacterial taxa are present on different surfaces and explore how they vary in growth dynamics and susceptibility to natural antimicrobials.

Both chili powder and honey powder demonstrated inhibitory effects, but chili powder consistently showed stronger suppression of bacterial growth across both experiments. Chili peppers contain capsaicinoids—compounds previously shown to possess antibacterial activity against species such as E. coli and Staphylococcus aureus (17). Liquid honey also demonstrated some antimicrobial properties, due in part to its low pH and hydrogen peroxide content (18). However, the

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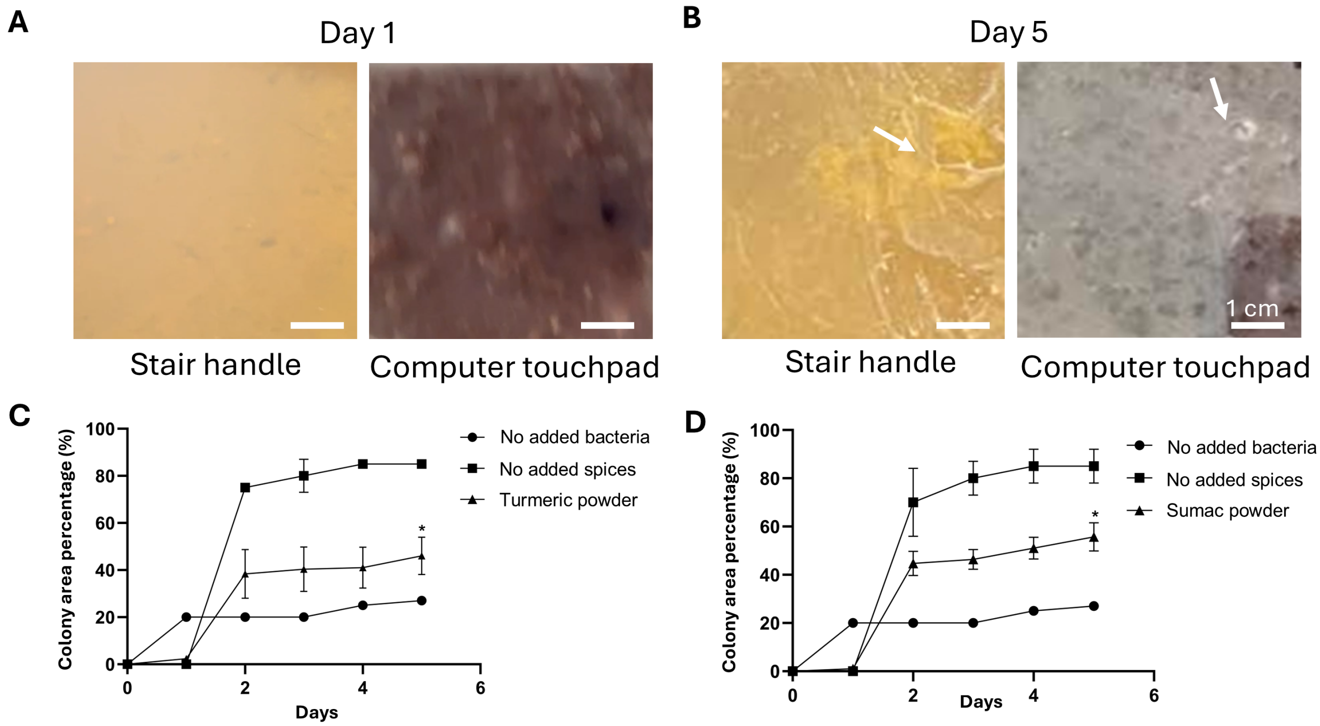

Figure 3. Effect of turmeric and sumac on bacteria collected from the stair handle and computer touchpad over time. (A, B) Bacteria were grown under control conditions, on sumac-treated agar plates, or on turmeric-treated agar plates over a period of 5 days (scale bar = 1 cm). Representative images of plates at (A) day 1 and (B) day 5. Bacterial growth can be seen as indicated by white arrows. (C) Line graph showing the average detected colony area percentage of bacteria collected from the stair handle and (D) computer touchpad. Plate coverage was quantified using ImageJ. Error bars represent standard deviation. Kruskal-Wallis test revealed statistical significance in differences in bacterial growth for bacteria collected from both the stair handle and computer touch pad (*$p < 0.05$, variable number of replicates).

powdered form of honey used in our study was less effective than chili powder. We suspect that the reduced antibacterial effect we observed in powdered honey may be due to processing methods, such as the deactivation of enzymatic components or the decrease in hydrogen peroxide content (18, 19). This explanation requires further experimental verification.

This study consisted of two independent student-led investigations, and each used original experimental designs. As a result, we should interpret the study as two parallel experiments rather than a single unified study. One limitation is that we did not test all spice treatments across all surface types, which restricts direct comparisons between conditions. Additionally, all experiments occurred in household environments in different geographic locations, where environmental contamination or variability in sterility may have influenced the results. This observation is supported by the minor growth we saw in our negative control for the turmeric and sumac experiment, suggesting potential background contamination (**Figure 3**). Increasing the number of replicates and including consistent environmental controls would improve the reliability of future experiments.

Turmeric, sumac, chili powder, and honey powder are widely available, cost-effective, and represent promising natural alternatives to chemical disinfectants that can have adverse environmental and health effects (20). Incorporating these spices into routine sanitation practices could help reduce microbial contamination in household and public settings. However, it is important to note that while our findings support the inhibitory potential of these spices under specific conditions, they do not confirm efficacy against all bacterial types or in all environments. Future research should explore the underlying mechanisms of action, test their effects on a broader spectrum of microorganisms, and evaluate their long-term use in diverse environments. Additional studies should also investigate optimal concentrations for antimicrobial effects (e.g. 1%, 5%, 10%), the role of temperature and humidity, and potential applications in healthcare or food preparation settings. Finally, future experiments should include a larger sample size, a greater variety of surfaces for sampling, and more standardized methods of quantifying bacterial growth. Ultimately, our work established that common kitchen ingredients exert antibacterial control over surface bacteria. Further investigation could provide individuals with a low-cost, readily accessible avenue for improved hygiene.

MATERIALS AND METHODS

All supplies used were pre-sterilized and included in a kit from the Journal of Emerging Investigators Mini PhD Program. Each experiment was conducted independently by two investigators in different geographical locations. The spices used were limited to availability in each student's household: Chili Powder (McCormick), Honey Powder (Cactus Gold), Organic Ground Turmeric (Central Market Organics), and Sumac (Eat Well Premium Foods). The conditions of these experiments were prepared according to **Tables 1 and 2**.

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Collecting bacteria from surfaces of interest

Centrifuge tubes were prepared with 5 mL of Tryptic Soy Broth (TSB) for bacterial collection. The surfaces of interest—including a stair handle, front door handle, shared computer touchpad, and a personal cellphone screen—were swabbed using sterile cotton swabs pre-moistened with sterile water. Once swabbed, the cotton applicators were inserted into the respective centrifuge tubes and mixed several times. The tubes were then loosely capped to allow limited aeration and stored at room temperature for two days to promote bacterial proliferation. The negative control consisted of sterile water only. The OD_{600} was measured for the chili powder and honey powder experiment using a spectrophotometer.

Bacterial subculture

To achieve a more homogeneous bacterial population, liquid cultures from the surfaces were streaked onto Luria-Bertani (LB) agar plates and incubated at room temperature for two days. Once a single colony was visible, it was transferred into a fresh TSB medium and grown for another two days at room temperature.

Agar plate preparation

LB agar was melted in the microwave and mixed with spices at a concentration of 4% (v/v) for treatment plates. Control plates and subculture plates contained no added spices. Approximately 20 mL of melted agar was poured into 10 cm Petri dishes and allowed to solidify for at least two hours at room temperature.

Bacterial growth

Using a sterile plastic Pasteur pipette, three drops of bacteria grown in broth were transferred onto the prepared agar plates. The suspension was evenly spread across the agar surface using an L-shaped plastic spreader. Plates were incubated at room temperature for five days, and bacterial growth was monitored by capturing daily images of each plate.

Colony analysis

The resulting bacterial colonies were analyzed using ImageJ (version 1.54e) (21). Surface area analysis was conducted to determine differences in bacterial growth dynamics between treatment groups. Each visible colony was quantified by area, and the percentage of plate coverage was used to compare treatment effectiveness.

Statistical analysis

Statistical analyses were performed using GraphPad Prism version 10.0. In the chili powder and honey powder experiment, a one-way ANOVA was used to determine if spice treatments produced significant differences in bacterial growth (n = 3 replicates per condition). In the turmeric and sumac experiment, a Kruskal–Wallis test was used to evaluate group differences (replicate numbers varied by condition). A p-value of less than 0.05 was considered statistically significant.

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