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Article

Household spices and minerals as alternative disinfectants for mobile phones

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SUMMARY

Mobile phones play an essential role in enhancing personal, social, and professional life in many ways, including to access to communication, information, and entertainment. However, mobile phones also come in contact with environments containing high densities of microorganisms, such as hospitals, schools, restrooms, and kitchens, suggesting that mobile phones could also act as carriers of disease. Commercial disinfectants are highly effective against potential human pathogens found on mobile phones, yet these disinfectants also contain chemicals that are toxic to both human health and the environment. In addition, there is evidence that modern microorganisms are becoming resistant to commercially available disinfectants. We hypothesized that household spices and minerals, such as garlic, mint, zinc, and iron, could act as alternate solutions for disinfecting mobile phones after daily use. Our results demonstrate that garlic, iron, and zinc are just as effective at suppressing microorganisms compared to commercially available cleaners, Clorox and Pine-Sol. These results could help guide further research aimed at producing more environmentally friendly cleaners and reducing the need for toxic chemicals in household disinfectants.

INTRODUCTION

Mobile phones play an essential role in personal, social, and professional life, as there are currently over six billion active cellular subscriptions worldwide (1). Advances in the applications available on these devices enable them to be used to enhance life in many different ways, for example: better communication, easy access to information, and entertainment. Due to their widespread use, mobile phones are constantly touched by humans that have interacted with environments containing high densities of microorganisms, such as hospitals, schools, restrooms, and kitchens. This suggests that despite the positive impacts of the technology, mobile phones could also act as a carrier of disease throughout the community (2, 3).

Although commercial household disinfectants are highly effective against potential human pathogens found on mobile phones, household cleaners can expose consumers to complex mixtures of potentially toxic chemicals, including quaternary ammonium compounds (QACs), alcohols, sodium hypochlorite (bleach), hydrogen peroxide, acids, and phenolic compounds (4). Exposure to such chemicals has been shown to increase the risk of asthma, chronic obstructive pulmonary disease, infertility, and inhibit cholesterol biosynthesis (5, 6). Due to the increased use of disinfectants worldwide in response to the COVID-19 pandemic, studies have recently focused on the impact of disinfectants on human health and safety (7).

In addition to unfavorable impacts on human health, the discharge of toxic chemicals found in household cleaners into wastewater have adverse effects on aquatic and plant life (8). The continuous exposure to common disinfectants may also increase microbial resistance by cellular mutations or acquisition genetic elements (9-11). Therefore, there is a need for alternative disinfectants that minimize undesirable impacts on human and environmental health while maintaining the potency needed to kill unwanted pathogens.

Studies have investigated the possibility of using natural products such as baking soda and vinegar as natural alternatives to commercial disinfectants (12, 13). These studies concluded that alternative baking soda and vinegar solutions are generally not as effective at completely killing microorganisms compared to other commercial disinfectants, but rather that they could potentially be used in cases where the user desires to clean surfaces in which complete elimination of microorganisms is unnecessary. Alternatively, it is well known that certain household spices and minerals have antimicrobial properties – there is even evidence of them targeting antibiotic-resistant bacteria (14-18). Here, we hypothesized that the antimicrobial properties of spices and minerals could be used as alternative disinfectants for mobile phones. Pine-Sol, Clorox, mint, garlic, zinc, and iron were tested based on previous reports of antimicrobial activity (14-18). In our experiments, we determined that garlic, iron, and zinc were just as effective at suppressing the growth of microorganisms found on mobile phones compared to the commercially available cleaners, Clorox and Pine-Sol. These results could help guide further research aimed at producing more environmentally friendly cleaners and reducing the need for toxic chemicals in household disinfectants.

RESULTS

To compare the effectiveness of spices, minerals, and commercial cleaners in killing microorganisms, we tested the ability of our supplemented reagents to permit the growth of mobile phone microbial subculture. Growth was observed on the positive control plates and the plates supplemented with mint (**Figure 1**). Additionally, we observed that the growth on the positive control and mint plates did not look the same, even though the same microbial subculture was applied to

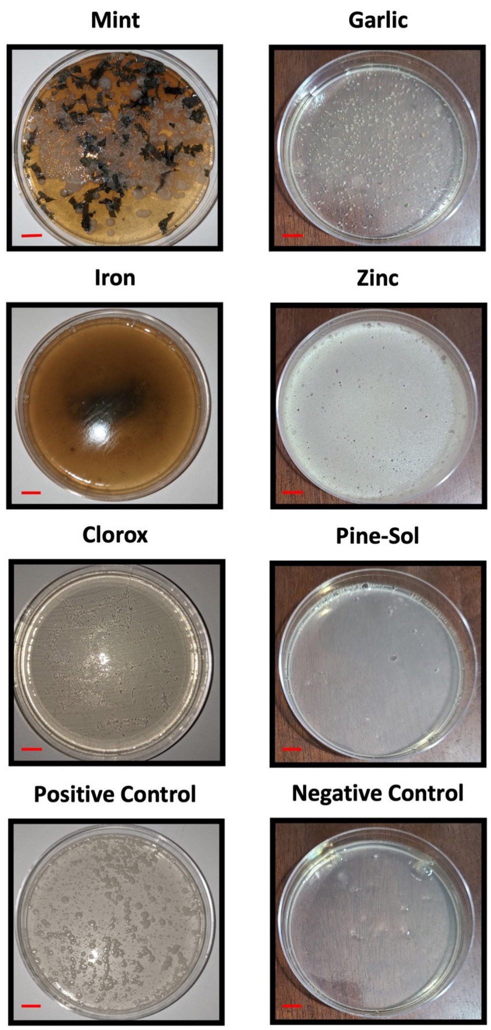

Figure 1: Representative images of subculture plates grown with spices, minerals, and commercial cleaners. Pictures were taken after one day of incubation at room temperature. Three replicates were recorded for each plate. The red scale bar represents a length of 1 cm.

both plates. The mint plate grew smaller colonies, which eventually overlapped. In contrast, the positive control grew larger colonies which were spread far apart. The average diameter of colonies on the mint and positive control plates were 0.3 ± 0.1 mm and 0.7 ± 0.2 mm, respectively (**Figure 2A**). Although the positive control had colonies spread throughout more of the plate, the densities of the colonies were similar on the mint and positive control plates, with observed densities of 11 ± 5 colonies/cm^2 and 9 ± 5 colonies/cm^2, respectively (**Figure 2B**).

We found that microbial growth was not observed on the negative control plates, in addition to plates supplemented with Clorox, Pine-Sol, iron, zinc, and garlic (**Figure 1**). We observed that the texture of each plate looks different due to the different additives. We concluded that Clorox, Pine-Sol, iron, zinc, and garlic can inhibit microbial growth of microorganisms found on mobile phones.

DISCUSSION

We hypothesized that all our tested spices, minerals, and commercial cleaners would mitigate growth of microorganisms cultured from mobile phones. Clorox, Pine-Sol, garlic, zinc, and iron were all effective at suppressing microbial growth. To contrast, microbial growth was observed on the plate containing mint. This was a surprising observation, as antimicrobial properties of mint have been reported previously (18). The mint used in this study was freshly picked and washed using sterile water, but it is possible that there were still naturally occurring microorganisms remaining on the mint before it was added to the agar. This explanation is supported by the observation that the microbial colonies looked visibly different on the positive control and mint plates. This suggests that the colonies grown on the plates were of different origins, which was not expected as a single colony was subcultured before being applied to the plates. In the future, the experiment should be repeated using dried mint (the same condition as the garlic used here) or using autoclaved mint, or we could confirm that the colonies were from different origins. Techniques such as Gram staining or by growing the cultures in differential media (e.g. blood agar) could be used to determine whether or not similar colonies are being compared across conditions.

Overall, these results demonstrate that garlic, zinc, and iron could potentially be used as alternatives to commercial cleaners when disinfecting mobile phones. We would like to

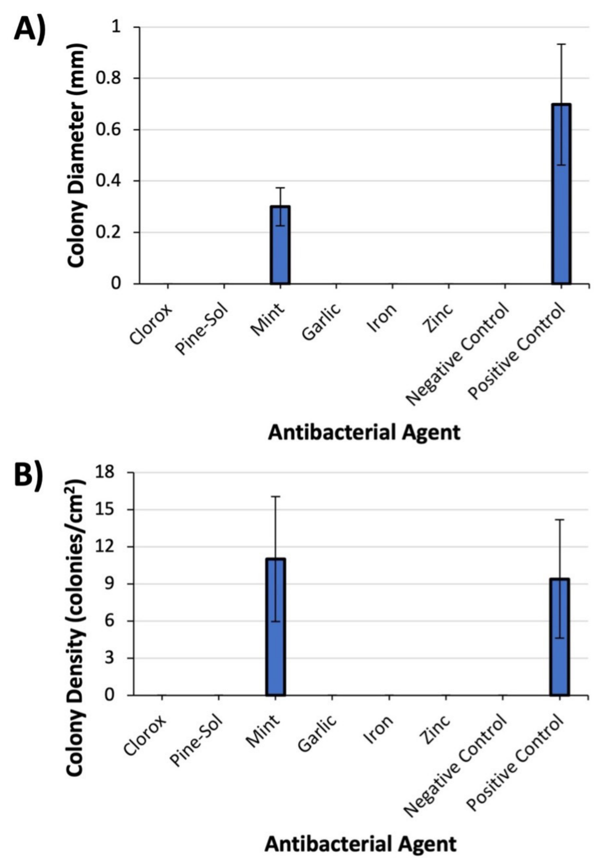

Figure 2: Microbial growth of mobile phone subcultures. A) Average diameter of colonies observed on each plate (n = 3). B) Average density of colonies observed on each plate (n = 3). Plates were allowed to incubate at room temperature for 1 day. Error bars represent the standard deviation of measurements made on three replicate plates.

further this research by investigating the minimum amount of each additive that is needed to kill the microorganisms found on mobile phones. Additionally, we would like to explore the application of solutions containing garlic, zinc, or iron directly to a phone, as this is how disinfection takes place in real-life applications. One obvious limitation to this idea is that garlic, zinc, and iron could all leave unwanted residue on the surface of the phone. Although it is possible that the lowest concentration needed to stop growth would not cause this, an alternative approach would be making disinfectants from essential oils, extracts, or metal salts containing the active ingredients of interest rather than a solution of the raw spice or mineral. We are also interested in investigating a greater number of spices and minerals to see if any are more effective at lower concentrations than those studied here.

To conclude, we demonstrate that garlic, zinc, and iron are just as effective at suppressing the growth of microorganisms found on mobile phones when compared to the commercially available cleaners, Clorox, and Pine-Sol. We envision that disinfectants containing these additives could be formulated to be used as alternatives to commercially available cleaners. If realized, this would help minimize the health and environmental impacts of commercial cleaners and help combat microorganisms that are resistant to currently available cleaners.

MATERIALS AND METHODS

Preparation of spices, minerals, and cleaners

Freshly grown mint was picked, washed using sterile water, and sliced and crushed as finely as possible. Garlic came prepackaged and dried, but was further crushed into powder before use. Iron and zinc supplements were obtained in 50 mg pills, which were crushed into a fine powder. Clorox and Pine-Sol were obtained in liquid form and were not modified prior to use.

Preparation of agar plates

Three replicate plates were prepared for each spice, mineral, commercial cleaner, negative control, and positive control. 1 mL of commercial cleaner (Clorox and Pine-Sol), 1 g of each spice (mint and garlic), and 50 mg of each mineral (iron and zinc) were added to separate, sterile Falcon tubes. Solid, sterile tryptic soy agar (TSA) was melted as recommended by the manufacturer and transferred to each falcon tube for a final volume of 15 mL. Each solution was mixed well using a sterile wooden dowel. The contents of each tube were then poured into sterile agar plates, which were then covered and left to solidify. For the negative and positive control, 15 mL of unmodified TSA were added the plates and left to cool in a similar manner. All plates were then stored at 4 °C prior to use.

Sample collection and inoculation of TSB liquid cultures

To prepare the liquid cultures for application onto the agar plates, they were first collected and incubated. Microorganisms were collected by swabbing the screen of a mobile phone back and forth five times using a sterile cotton swab. The entire swab was then deposited into a test tube containing 4 mL of sterile tryptic soy broth (TSB), which was sealed and lightly shaken for 5 seconds to mix. An uncontaminated sterile swab was placed in a test tube with TSB and shaken in a similar manner for the negative control. Both test tubes were incubated at room temperature for 3 days.

Microbial subculturing

One drop (~50 μL) of positive TSB culture was placed onto an agar plate and evenly spread using a sterile spreader. The same was done for the negative control. The plates incubated for 1 day at room temperature. After incubation, a single colony was isolated from the plate and placed into a new test tube containing 4 mL of TSB using a sterile wooden dowel. The tube was sealed and shaken. In a similar manner, a new sterile wooden dowel was placed in a test tube with TSB for the negative control. Both cultures were left to incubate at room temperature for 3 days.

Supplemented growth experiments with subcultured microorganisms

Positive and negative TSB subcultures were diluted 1:100,000 in TSB. One drop (~50 μL) of diluted subculture was placed on the garlic, mint, iron, zinc, Clorox, Pine-Sol, positive control, and negative control plates. The plates were incubated at room temperature for 1 day.

Data collection and analysis

Pictures of each plate were taken using a cell phone camera. The pictures were imported into Microsoft PowerPoint and normalized according to their actual dimensions. The diameter of each colony was measured using the ruler function in PowerPoint. The area which colonies occupied on each plate was also estimated using the ruler in PowerPoint. All data was analyzed and plotted using Microsoft Excel.

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