



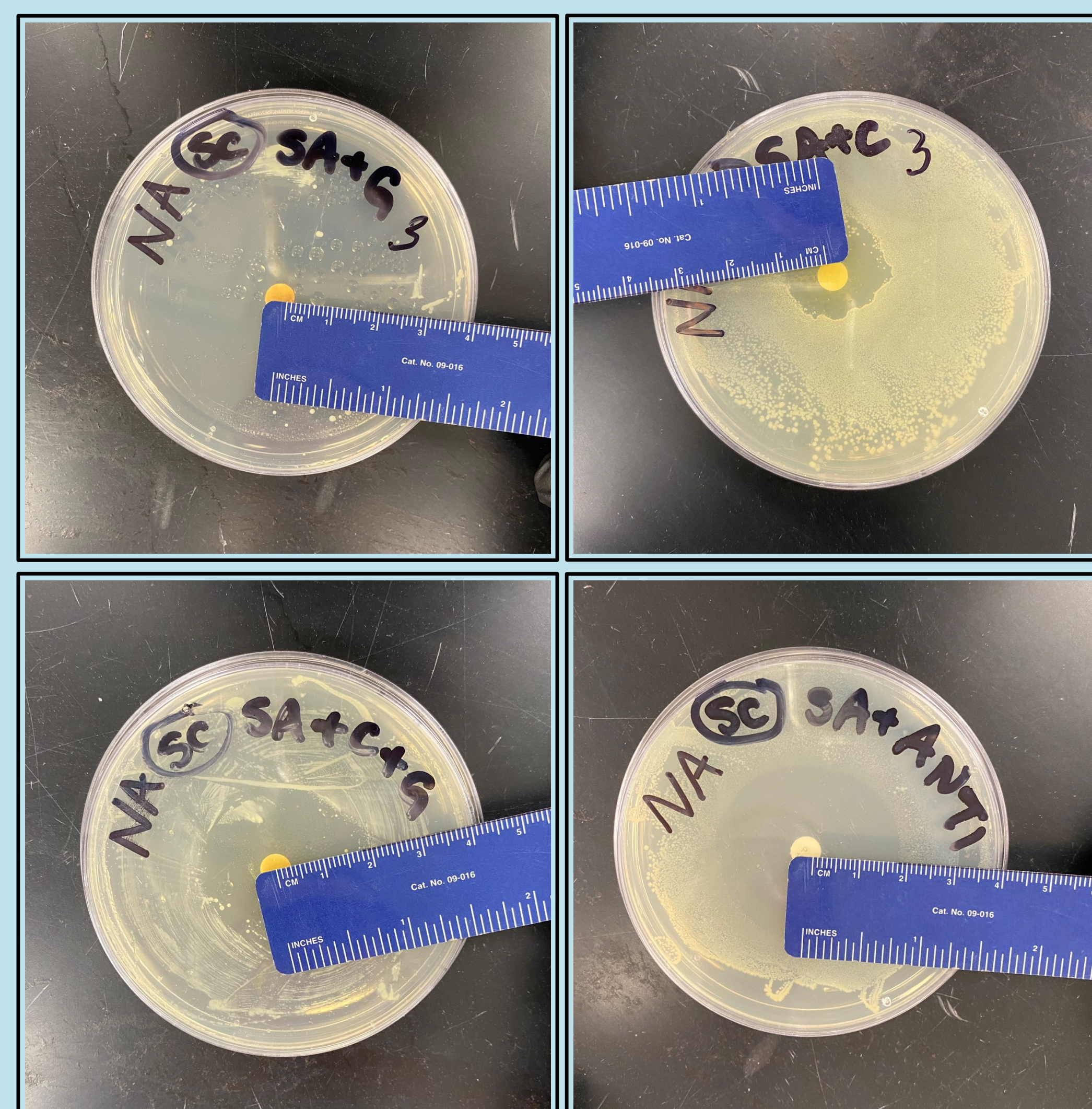
The antibacterial effect of clove (*Syzygium aromaticum*), garlic (*Allium sativum*), and the combination of both

Sarah Clemons and Ashley Spring, Ph.D.
Eastern Florida State College



Introduction

Staphylococcus aureus and *Pseudomonas aeruginosa* are pathogenic bacteria causing infections in humans with 32,600 multidrug-resistant cases of *P. aeruginosa* and 119,000 cases of *S. aureus* in 2017 (Centers for Disease Control, 2019). Although antibiotics are used to treat both pathogenic bacteria, both species have antibiotic-resistant strains (Magryś et al. 2021). Natural products, including clove (*Syzygium aromaticum*) and garlic (*Allium sativum*), have demonstrated antibacterial effects against *S. aureus* and *P. aeruginosa* (Betoni et al. 2006) (Jabeen et al. 2014). The hypothesis of this study is clove (*S. aromaticum*), garlic (*A. sativum*), and the combination of both will have a significant antibacterial effect on the growth of *S. aureus* and *P. aeruginosa*.



Material and Methods

- 36 Petri dishes with nutrient agar
- Clove oil (*S. aromaticum*)
- Garlic oil (*A. sativum*)
- 9 antibiotic disks (penicillin)
- 6 blank disks

The petri dishes were prepared with nutrient agar and bacteria (*S. aureus* or *P. aeruginosa*). A disk was placed in the center each Petri dish with either antibiotic (penicillin), clove (*S. aromaticum*), garlic (*A. sativum*), the combination of clove (*S. aromaticum*) and garlic (*A. sativum*), or blank (control). The Petri dishes were incubated for 48 hours at 37 °C, and zones of inhibition were measured at 24 and 48 hours.

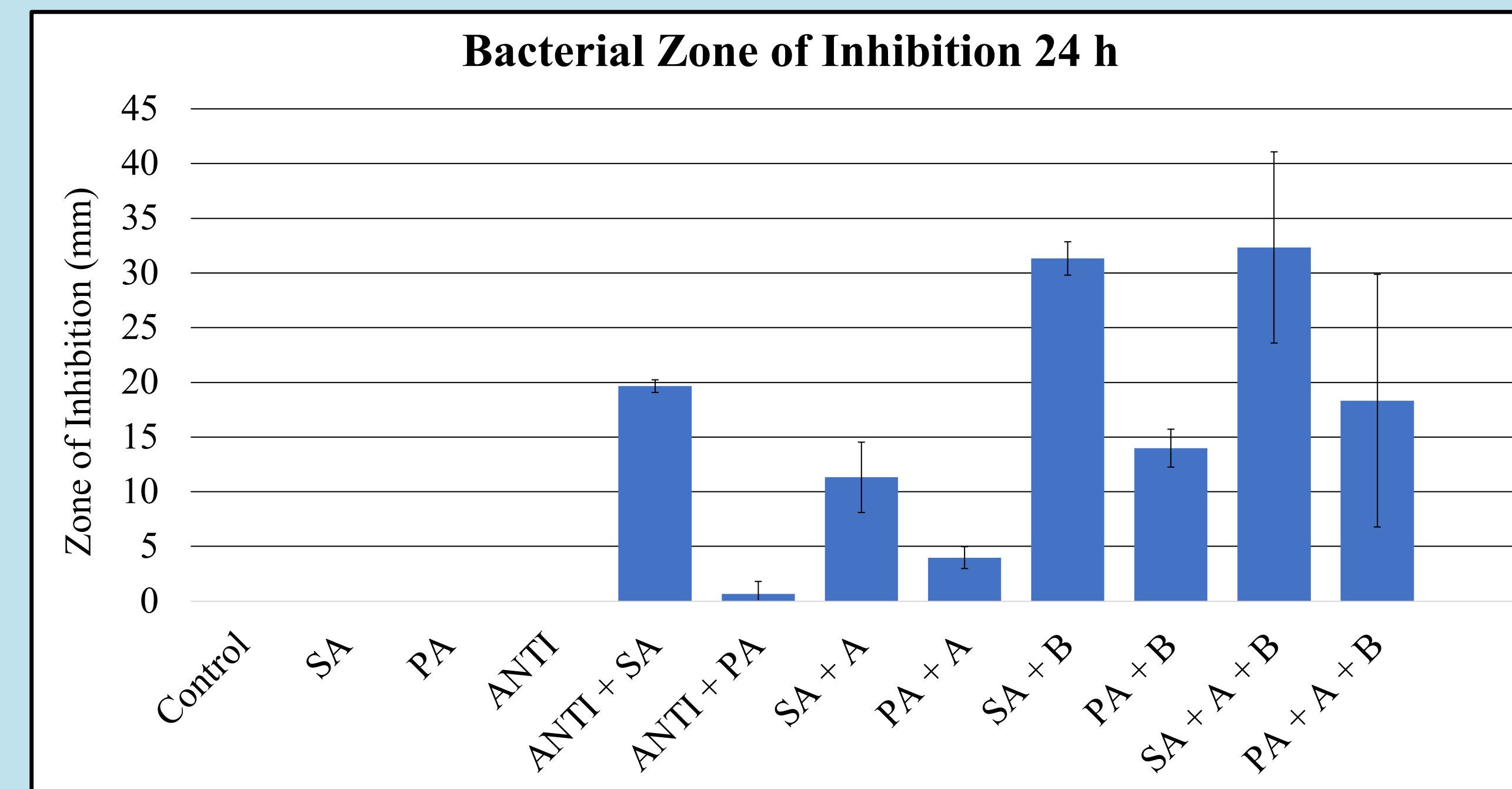


Figure 1. Zone of Inhibition (mm) of *S. aureus* (SA) and *P. aeruginosa* (PA) grown on nutrient agar with natural products of A=clove (*S. aromaticum*), B=garlic (*A. sativum*), A+B=clove and garlic, ANTI=antibiotic (penicillin) (mean ± SD).

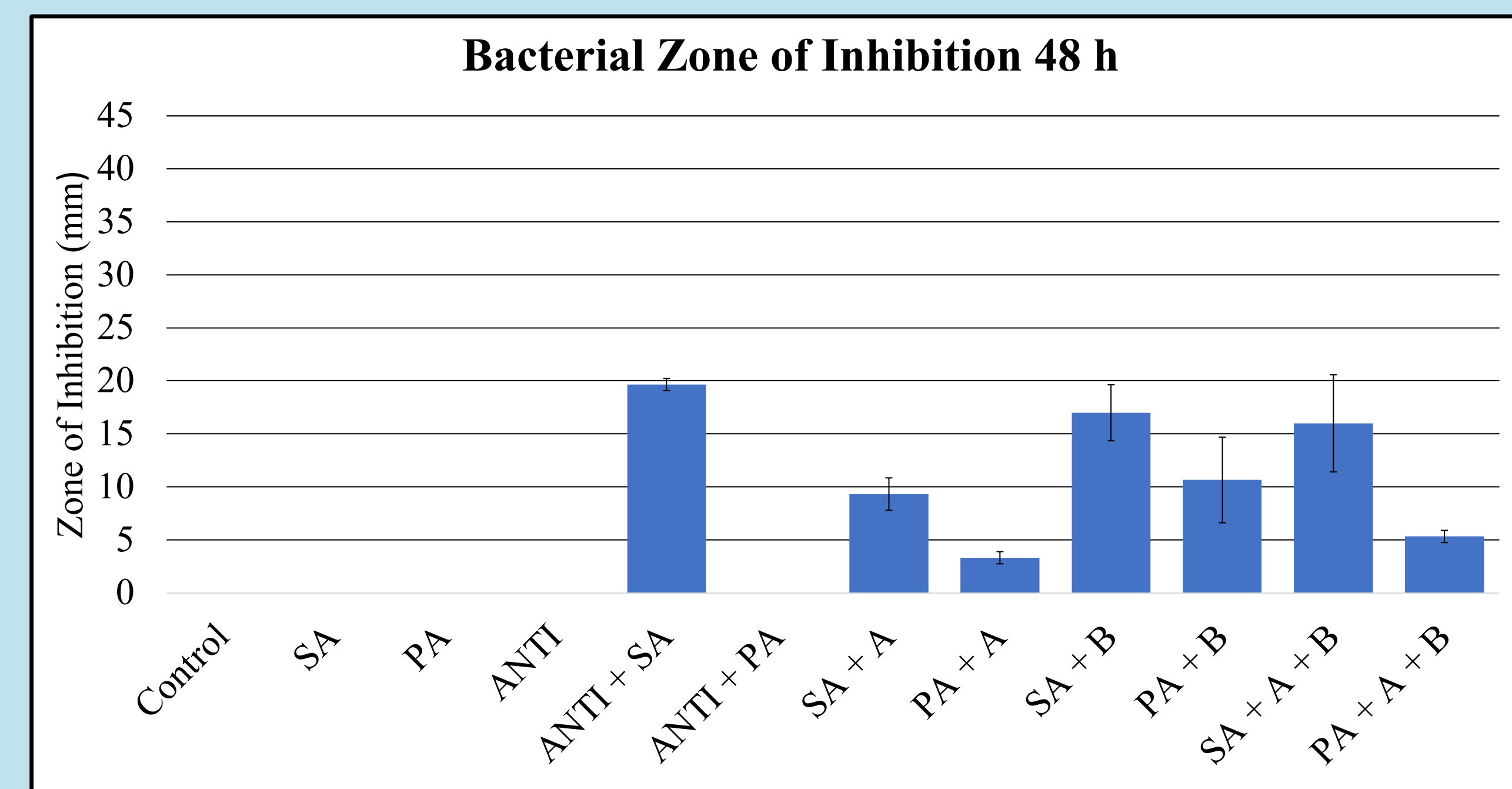
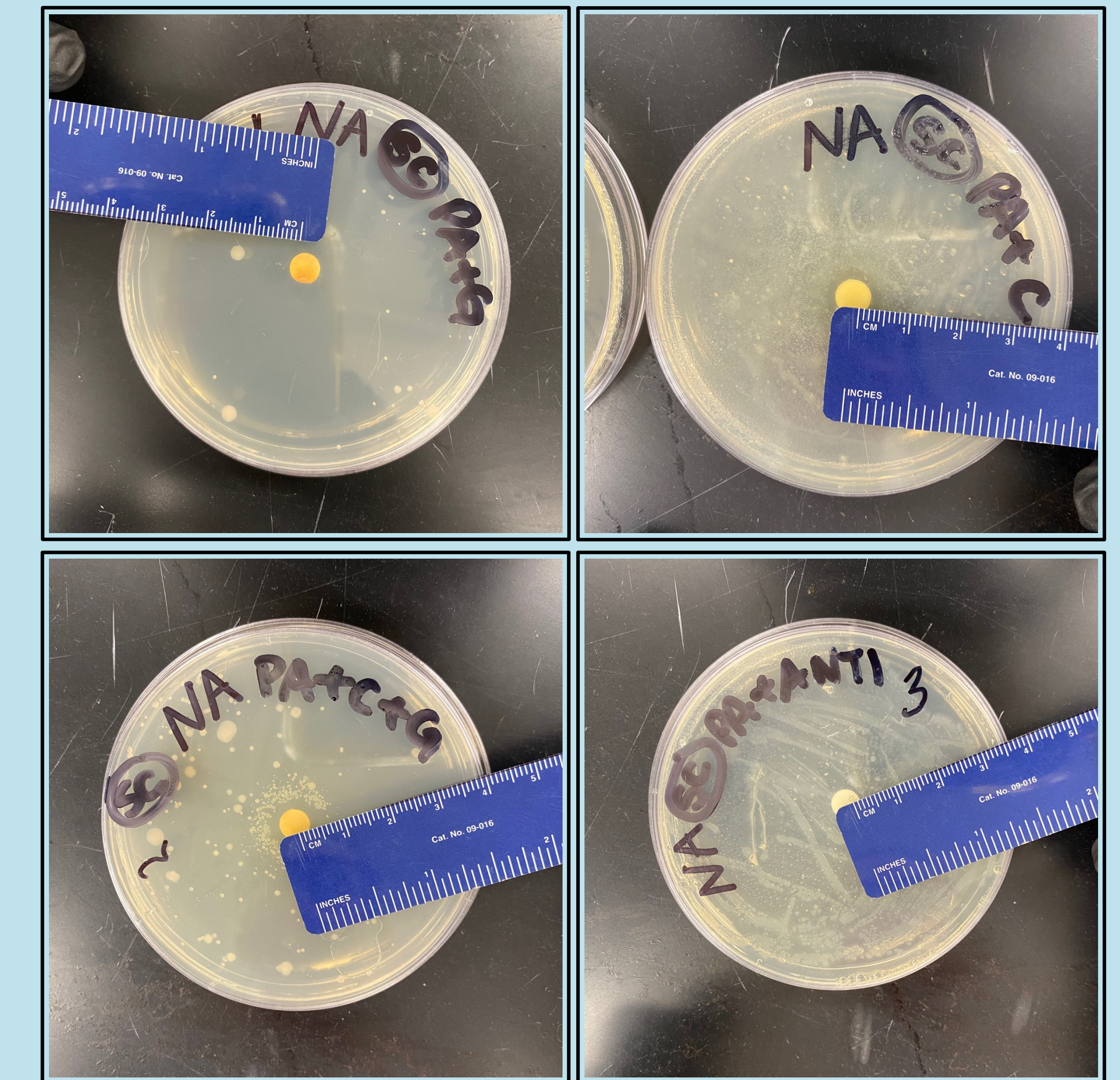


Figure 2. Zone of Inhibition (mm) of *S. aureus* (SA) and *P. aeruginosa* (PA) grown on nutrient agar with natural products of A=clove (*S. aromaticum*), B=garlic (*A. sativum*), A+B=clove and garlic, ANTI=antibiotic (penicillin) (mean ± SD).

Results

There is a significant difference between the zone of inhibition of bacteria (*S. aureus* and *P. aeruginosa*) exposed to antibiotic (penicillin), clove (*S. aromaticum*), garlic (*A. sativum*), and both clove and garlic after 24 hours (1-way ANOVA, $F_{11,24}=23.63$, $p<0.05$).

There is a significant difference between the zone of inhibition of bacteria (*S. aureus* and *P. aeruginosa*) exposed to antibiotic (penicillin), clove (*S. aromaticum*), garlic (*A. sativum*), and both clove and garlic after 48 hours (1-way ANOVA, $F_{11,24}=42.63$, $p<0.05$).



Discussion

The data supports the hypothesis that clove (*S. aromaticum*), garlic (*A. sativum*), and the combination of both have significant antibacterial effect on the growth of *S. aureus* and *P. aeruginosa*. The antibiotic (penicillin) used did not greatly inhibit the growth of the *P. aeruginosa*. The garlic (*A. sativum*) by itself inhibited more growth of the *P. aeruginosa* vs. the clove (*S. aromaticum*), or the combination of both. The antibiotic (penicillin) worked the best on *S. aureus* though and after that garlic (*A. sativum*) or the combination of both were very similar. Jabeen et al. (2014) also reported reduction in growth of *P. aeruginosa* when exposed to clove (*S. aromaticum*) and garlic (*A. sativum*) and Betoni et al. (2006) reported reduction in growth of *S. aureus* when exposed to clove (*S. aromaticum*) and garlic (*A. sativum*). The impact of this research shows that clove (*S. aromaticum*), garlic (*A. sativum*), and the combination of both have potential to be used for antibacterial effects. Further research may study the interactions of clove (*S. aromaticum*) and garlic (*A. sativum*) with known antibiotic resistance strains and synergy with other antibacterial products.

Literature Cited

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