Exploring Gut Biofilm Dynamics: Effects of TiO_2, Antibiotics, and Probiotics in the Small Intestine

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Background and Significance

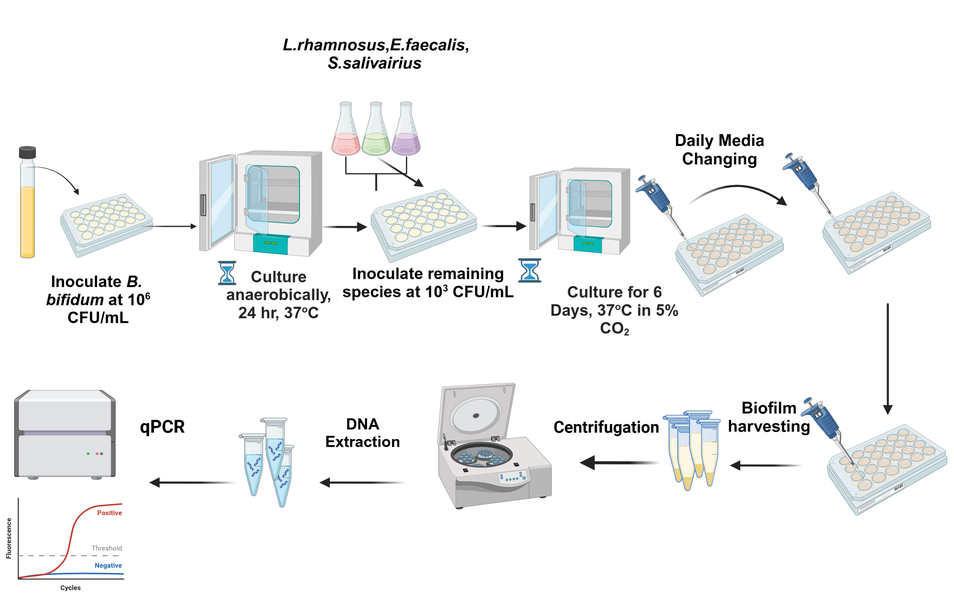
Chemicals like nanoparticles and antibiotics are increasingly integrated into daily life, raising concerns about their unintended impacts on gut microbiota, a vital component of human health.

- ❑ The gut microbiota supports critical processes such as nutrient absorption, immune regulation, and gastrointestinal function. Disruption of this microbial ecosystem can impair these processes and increase the risk of gut-related diseases.
- ❑ Titanium dioxide (TiO_2), a widely used food additive, and antibiotics are known to disrupt gut microbial communities. These disruptions highlight the need for strategies to mitigate their adverse effects. Probiotics, which are live microorganisms capable of stabilizing and protecting the gut microbiome, are a promising intervention.

Objectives

1. Assess the effect of probiotics on the stability and resilience of an established microbiome.
2. Examine the dose-dependent effects of titanium dioxide (TiO_2) nanoparticles on a synthetic small intestine microbiome.
3. Study the selective impacts of doxycycline on specific bacterial populations of established synthetic small intestine microbiome.

Methods



Results

Establishment of Four Species Biofilm

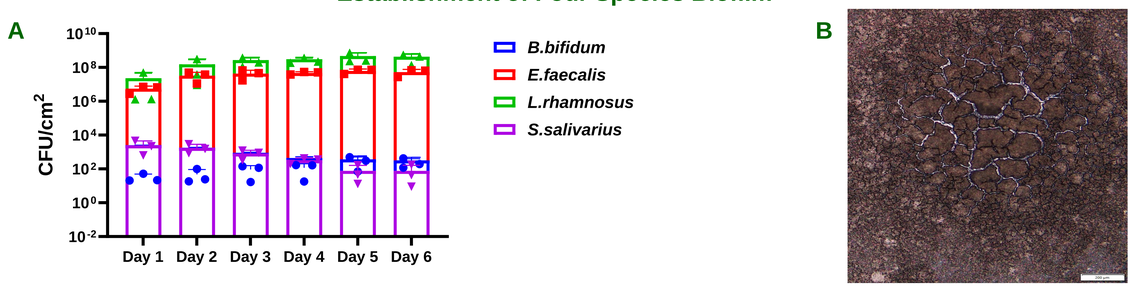


Figure 1. Biofilms with 4 relevant small intestine bacterial species. Biofilms were cultured for a total period of 6 days. *B. bifidum* was seeded for 24 hours under anaerobic conditions, after which *E. faecalis*, *L. rhamnosus*, and *S. salivarius* were introduced. Biofilms were harvested at 24-hour intervals and 16S rDNA was used to quantify bacterial cell numbers (**A**) while microscopy was used to visualize biofilms (**B**). Results consist of triplicate biological experiments and error bars represent SD.

Effect of Probiotics on Four Species Biofilm

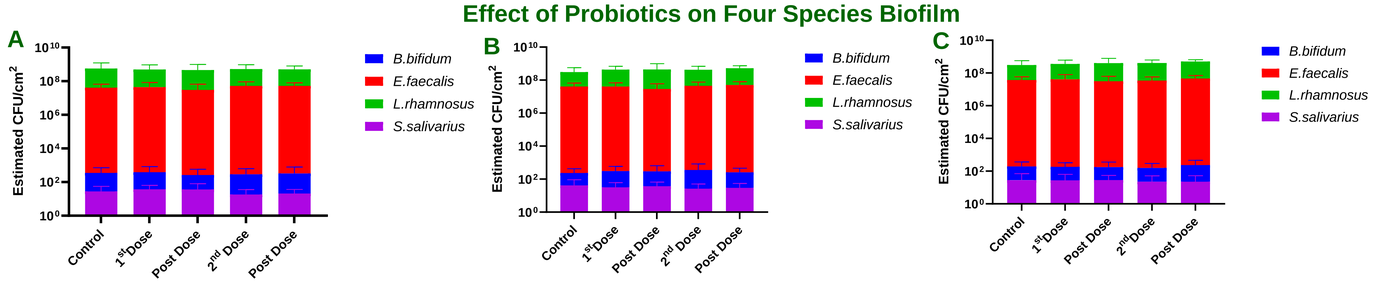


Figure 2. Effect of probiotics on the biofilm bacterial population. Once steady state was reached, biofilms were exposed to *L. rhamnosus* (**A**), *B. bifidum* (**B**) or both (**C**) in a dose dependent manner to mimic digestion. 16S rDNA was used to quantify bacterial cell numbers and results consist of triplicate data and error bars represent SD.

Effect of TiO_2 on Biofilms

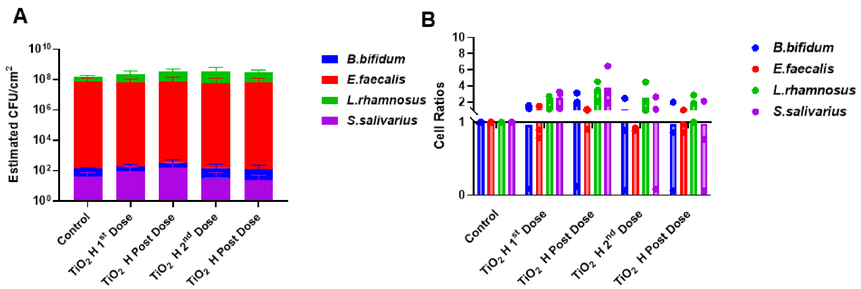


Figure 3. Effect of TiO_2 on the biofilm stability. Once steady state was reached, biofilms were exposed to High doses of TiO_2 NPs (A) Effect of TiO_2 ,(B) Ratio graph comparing to control.16S rDNA was used to quantify bacterial cell numbers and results consist of triplicate data and error bars represent SD.

Effect of Doxycycline on Biofilms

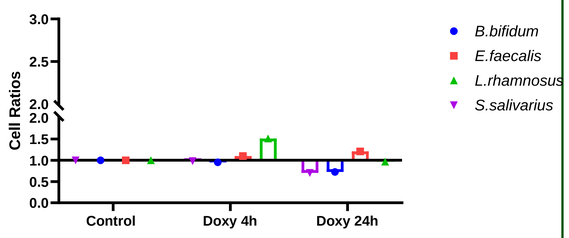


Figure 4. Effect of doxycycline on the biofilm stability. Once steady state was reached, biofilms were exposed to doxycycline for 4 and 24 hours. 16S rDNA was used to quantify bacterial cell numbers and results consist of triplicate data and error bars represent SD.

Conclusions

- ❑ This study demonstrates the resilience and stability of established gut microbial biofilms, as probiotics alone did not significantly disrupt their composition or function.
- ❑ Although high doses of titanium dioxide nanoparticles do not significantly disrupt the bacterial ratios in biofilms, they may affect them at the transcriptomic level.
- ❑ Similarly, doxycycline selectively impacted *S. salivarius*, and *B.bifidum* a bit further emphasizing its targeted effects on microbial composition. These findings highlight the differential impacts of external agents on gut microbiota and the role of probiotics in maintaining microbial stability.

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Lab Members.

References