Title:

Binding of nanoplastics by a novel biofilm postbiotic Qi601

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Introduction:

Widespread in the environment and consumer goods such as food and water, micro- and nanoplastics (MNPs) have been found in multiple human tissues most likely following dietary ingestion. Systemic absorption is inversely proportional to particle size. Therefore, nanoplastics are more likely to cross the intestinal barrier than microplastics. As MNPs effects on humans are unknown, there is a need for the safe prevention of absorption of ingested plastics. This study tested whether a postbiotic derived from L. fermentum biofilms (FDA GRAS Notice No. GRN 000988, 2022), could serve as an ingestible mitigant against dietary nanoplastics.

Methods:

Postbiotic ("Qi601" produced by heat-inactivating L. fermentum LfQi6 biofilms) was incubated (OD600 4.0, 1:200 v/v in water) with native polystyrene nanoparticles (2.28 x 10>9 particles/ml; 100 nm, Polysciences USA) for 1 hour. Supernatant containing unbound nanoplastic was removed. Sediment containing Qi601-bound nanoplastic was rinsed and 20 uL drops dried (1:100,000 v/v in water) onto clean uncoated microscope slides. Samples of postbiotic and NPs alone and NPs combined with postbiotic were imaged by atomic force microscopy (nGauge AFM, ICSPI Corp). Qi601 was also incubated with fed-state synthetic gastric fluid (Biochemazone, Canada) with fluorescent nanoplastics (4.55 x 10>11 particles/ml) for 1 hour and nanoplastics binding efficiency calculated based on remaining fluorescence of unbound particles in the supernatant.

Results:

AFM of NPs incubated with Qi601 showed widespread NP aggregation on postbiotic biofilms. Dense covering of Qi601 by NPs was consistent with efficient NP binding (see Figure). AFM of NPs showed mainly single NPs ~100 nm in size. Images of Qi601 postbiotic showed large clusters of intact bacteria consistent with scaled biofilm manufacturing method. Qi601 nanoplastic binding efficiency in gastric fluid was 98%.

Conclusion:

Biofilms cell walls are characterized by extracellular polymeric substances (EPS) -- biomaterials which enable biofilms to efficiently bind hydrophobic materials, including MNPs. Pathogenic biofilms readily form on and adhere to MNPs, creating hotspots of antibiotic resistance gene transfer and niduses for co-adsorbed toxins such as heavy metals and persistent organic pollutants. Human intestinal tract colonization with such biofilms is undesirable. This abstract represents the first evaluation of a non-viable biofilm, Qi601, for MNP binding (Patent Application: QBR.110P Monsul P et al. Materials and methods for removal of microplastics from fluids, the environment and biological systems. May 2025). As a heat-inactivated biofilm of a GRAS probiotic, Qi601 is a safe and inexpensive manufacturing-enabled ingestible biomaterial to protect against dietary nanoplastic absorption. Qi601 postbiotic significantly decreases probability of systemic absorption by rapidly and efficiently binding plastic NPs into microscale aggregates in water and simulated gastric fluid. This indicates the potential of Qi601 to bind NPs in environments such as the human intestinal tract lumen to prevent systemic uptake of dietary nanoplastics. The use of Qi601 as a heat-killed biofilm avoids potential complications associated with intestinal tract colonization by live biofilms. Future studies include MNP binding in an animal model and in vitro human intestinal barrier studies.

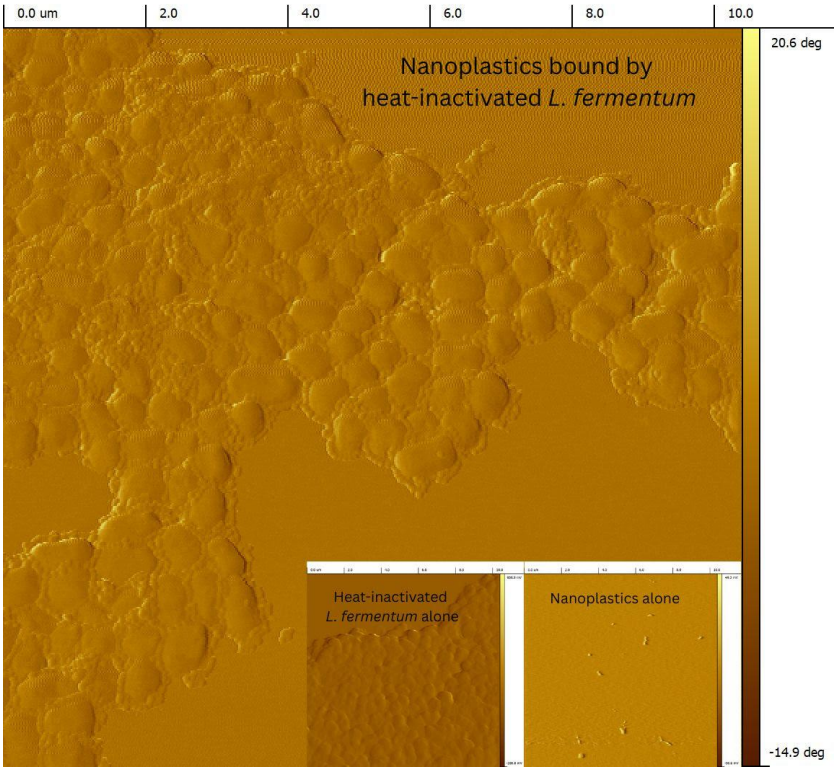

Figure. Heat-inactivated *L. fermentum* postbiotic Qi601 rapidly binds native polystyrene nanoplastics (NPs). AFM was performed on samples containing NPs with Qi601 (large image), and Qi601 and NPs alone (inset images). Dense coverings of 100 nm nanoplastics are observed on Qi601 biofilm aggregates.