The role of caffeine, nicotine and theobromine in the biodiversity and function of the human gut microbiome

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Abstract

The human gut microbiome plays a fundamental role in the regulation and maintenance of physiological processes and homeostatic relationships in the body, with research thoroughly proving its effects beyond gastrointestinal functioning such as in immune response, psychological operation, and nutritional metabolism. Caffeine, nicotine, and theobromine—the principal bioactive compounds in regularly consumed products like coffee, cigarettes, and dark chocolate, respectively—may yield significant and variable influences on human health beyond their normal pharmacodynamics through affecting gut microbiota. Using metagenomic modeling, predictions can be determined regarding intestinal community activity as well. I hypothesize that caffeine, nicotine, and theobromine will alter microbial community composition in a time- and dose-dependent manner relative to negative and solvent controls.

Introduction

• The gastrointestinal tract, one of the biggest internal interfaces between host and environment in the human body, contains an estimate of over 10^{14} microbes.1
• With over three million genes in the genome of the gut microbiome compared to the normal human genome of 23,000 genes, the vast variety of microbes and metabolites they produce presents a wide potential for effects on human health.1

Question: How do caffeine, nicotine, and theobromine each affect the microbiome, and how might functional predictions be made from drug exposure?

Compounds

<table>
<thead>
<tr>
<th>Caffeine</th>
<th>Nicotine</th>
<th>Theobromine</th>
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<td>With 85% of the United States population consuming at least one caffeinated drink daily, caffeine is one of the most widely ingested food components. Long-term caffeine consumption has been linked to lowered rates of developing conditions contingent on the intestinal ecosystem, like hepatic inflammation and obesity.4 Caffeine also influences brain health through short-chain fatty acids owing to the gut-brain relationship.2</td>
<td>Nicotine, the primary substance in tobacco products like cigarettes and vapes, remains the main addictive component behind the estimated 1.1 billion smokers around the world.5 Empirical research has found nicotine to be associated with abnormal microbial diversity in the gut related to the development of pathogenic species associated with Crohn’s disease, ulcerative colitis, and other inflammatory bowel diseases.6</td>
<td>Theobromine, the principal bioactive compound in dark chocolate, has been associated with the nutrient and antioxidant benefits involved in cocoa consumption, though it has seen less research relative to its sister xanthine-derivative caffeine.7 Nevertheless, theobromine has been linked with preventative effects against pathogenic bacteria in the gut microbiome, such as E. coli and related IgA-coated species.3</td>
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