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FROM POLLUTANT TO PILL: CAN MICROPLASTICS IN FOOD BE RECLAIMED FOR PARACETAMOL PRODUCTION

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ABSTRACT

The presence of microplastics in food has emerged as a major public health issue. At the same time, waste plastic may now be turned into valuable medications like paracetamol thanks to synthetic biology. With an emphasis on technological viability, existing obstacles, and wider ramifications for pharmaceutical innovation and environmental health, this mini-review investigates whether foodborne microplastics may be a sustainable feedstock for pharmaceutical manufacturing.

Keywords*: Microplastic, Synthetic biology, Paracetamol, Technology, Health*

INTRODUCTION

According to Smith et al. (2018), microplastics, which are plastic particles smaller than 5 mm, are now present in almost every food item in the world, including fruits, vegetables, seafood, salt, and drinking water [1]. These particles might endanger both ecological equilibrium and human health. The capacity of microbial biotechnology to transform plastic garbage into necessary medications like paracetamol is an unanticipated intersection of pharmaceutical innovation and environmental research [2]. This raises the intriguing question of whether the contaminants found in our food may be turned into medicinal remedies.

THE THREAT OF MICROPLASTICS IN THE FOOD CHAIN

Microplastics are formed when bigger plastics degrade and enter the food chain through soil, water, air, and processing materials [3]. According to research, individuals may consume millions of microplastic particles each year, however their physiological implications are still being studied [4]. Chemical additions like phthalates and bisphenol A increase its toxicity. Despite growing concern, present recycling methods cannot manage particles on such small dimensions, especially when incorporated in biological components.

BREAKTHROUGH: PLASTIC TO PARACETAMOL VIA SYNTHETIC BIOLOGY

Recent developments have demonstrated the enzymatic breakdown of polyethylene terephthalate (PET), a popular plastic used in bottles, into its monomers, ethylene glycol and terephthalic acid (TPA) [2, 5]. Researchers expanded on this by genetically modifying Escherichia coli to biosynthesise paracetamol and metabolise TPA [2]. Green chemistry and the circular bioeconomy are promoted by this biosynthetic approach, which substitutes cleaner, more energy-efficient processes for hazardous chemical ones.

CAN FOODBORNE MICROPLASTICS SERVE AS FEEDSTOCK

Mostly composed of PET or related polymers, foodborne microplastics may be vulnerable to enzymatic and microbial degradation [5, 6]. However, extraction and homogeneity are challenging due to their low concentration and diversity [4, 7]. Microbial cultures used in bioproduction are at risk from contaminants like heavy metals and organic toxins [3, 8]. It is difficult and expensive to isolate and sterilise foodborne microplastics for use in pharmaceuticals [9, 10]. Low yield, hazardous additives, polymer heterogeneity, and food safety issues are some of the difficulties associated with using foodborne microplastics as feedstock for the production of paracetamol [7, 8]. The possibility of employing foodborne microplastics as a feedstock for pharmaceutical manufacturing is still of interest in spite of these obstacles [11, 12].

IMPLICATIONS FOR CIRCULAR BIOECONOMY

Pharmaceutical biosynthesis and plastic waste valorisation are closely aligned with the goals of a circular bioeconomy, which allows environmental pollutants to be converted into necessary pharmaceuticals—a dual solution to global challenges [10]. This environmentally friendly method lessens reliance on dangerous chemicals and petrochemical feedstocks that are frequently used to produce paracetamol [13]. Rapid reprogrammability provided by bio-based platforms enables the redesign of microbial chassis for the production of additional aromatic drugs from PET waste [14]. Using plastic-derived substrates, similar engineered microbes can be repurposed for multiple therapeutic targets, marking a paradigm shift in green pharmaceutical manufacturing [15, 16].

CHALLENGES, FUTURE PROSPECTS, SCIENTIFIC OUTLOOK, STRATEGIC POTENTIAL

Through modular engineering of catabolic and biosynthetic pathways, advanced synthetic biology provides the possibility of upcycling complex or impure plastic sources, allowing for the microbial degradation of heterogeneous polymers [6]. Plastic-to-drug bio refineries can help address the twin crises of environmental waste and medicine scarcity, which is especially pertinent in areas with plastic pollution and pharmaceutical shortages [2]. Nevertheless, the pathway has drawbacks like low titers, cofactor imbalances, and by-product inhibition, which necessitate co-optimization of flux balance and redox and are typical metabolic constraints in engineered microbes [12]. With programmable control over gene expression and network dynamics, advanced metabolic engineering, CRISPR-based genome editing, and AI-driven pathway optimisation can improve yields [17-20].

In order to overcome metabolic bottlenecks, increase pathway modularity, and prevent intracellular toxicity, future research may concentrate on microbial consortia or cell-free enzymatic cascades [21, 22]. Because of biosafety and environmental containment concerns, it is imperative to address concerns regarding genetically modified organisms (GMOs) and bioreactor contamination, particularly in large-scale production settings [23].

These tactics could be especially revolutionary in low-income, resource-constrained environments where plastic pollution is a major problem and traditional supply chains are unable to meet pharmaceutical demands.

CONCLUSION

The technology of turning foodborne microplastics into paracetamol has the potential to address global issues such as pollution and healthcare access. Synthetic biology offers a new perspective on pollution, viewing it as a raw material for healing rather than a threat. The microbial conversion of plastic waste into paracetamol exemplifies the power of synthetic biology in addressing these issues. As the world faces plastic accumulation and drug shortages, these innovations may redefine how medicines are manufactured sustainably, affordably, and circularly. The microbial conversion of clean PET into paracetamol sets the precedent for reframing threats as opportunities, and if scientific and regulatory challenges are overcome, foodborne microplastics may shift from contamination to cure.

CONFLICT OF INTEREST

No

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