

## Microorganism Utilization for Synthetic Milk

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### Abstract

A desired architecture for long duration spaceflight, like aboard the International Space Station or for future missions to Mars, is to provide a supply of fresh food crops for the astronauts. However, some crops can create a high proportion of inedible plant waste. The main goal of the Synthetic Biology project, Cow in a Column, was to produce the components of milk (sugar, lipid, protein) from inedible plant waste by utilizing microorganisms (fungi, yeast, bacteria). Of particular interest was utilizing the valuable polysaccharide, cellulose, found in plant waste, to naturally fuel- through microorganism cellular metabolism- the creation of sugar (glucose), lipid (milk fat), and protein (casein) in order to produce a synthetic edible food product. Environmental conditions such as pH, temperature, carbon source, aeration, and choice microorganisms were optimized in the laboratory and the desired end-products, sugars and lipids, were analyzed. *Trichoderma reesei*, a known cellulolytic fungus, was utilized to drive the production of glucose, with the intent that the produced glucose would serve as the carbon source for milk fat production and be a substitute for the milk sugar lactose. Lipid production would be carried out by *Rhodosporidium toruloides*, yeast known to accumulate those lipids that are typically found in milk fat. Results showed that glucose and total lipid content were below what was expected during this phase of experimentation. In addition, individual analysis of six fatty acids revealed that the percentage of each fatty acid was lower than naturally produced bovine milk. Overall, this research indicates that microorganisms could be utilized to breakdown inedible solid waste to produce useable products. For future work, the production of the casein protein for milk would require the development of a genetically modified organism, which was beyond the scope of the original project. Additional trials would be needed to further refine the required environment/organisms for the production of desired sugar and lipid end-products.