

Microalgal Production of Biodiesel and Lutein

Title of Technical Report

(Technical Report)

Safety and Profit: A Symbiotic Relationship

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

Pablo Alejandro Newton Suárez

Spring, 2024

Department of Chemical Engineering

Table of Contents

Executive Summary	6
Microalgal Production of Biodiesel and Lutein	9
Safety and Profit: A Symbiotic Relationship	117
Prospectus	134

EXECUTIVE SUMMARY

The matters of safety concern not only societal and human safety but also environmental safety. Often times, safety is neglected in the pursuit of further profits so methods that are able to prioritize safety for the environment and society while maintaining a profit. As a result, the next step in developing sustainable engineering is producing the tools and mindsets necessary to bring about the conditions that allow for all three of the aforementioned goals to be reached. To these ends, the pursuit of environmental safety can be primarily relegated to the underlying industrial processes. As a result, my team and I sought to design a plant capable of producing carbon neutral biodiesel from algae while using a side product, Lutein, to offset costs and make a profit. On the societal safety side, this paper attempts to identify where the preconceived notions that safety and profitability are competing focuses comes from and how to move away from that perspective.

The technical portion of this thesis approached the problem of designing a biodiesel production plant from algae, specifically *Chlorella Vulgaris*. This plant would also produce a highly valuable side product in the form of Lutein, a nutritional supplement. This design was produced through a variety of methods including simulations, lab scale research, and mathematical models.

The technical portion of this thesis unfortunately concluded that the extraction of FAME biodiesel and Lutein from *Chlorella Vulgaris* is not economically viable. Due to the high costs in the upstream portion of the process including drying and growing, the proposed plant runs at approximately \$279 million in losses per year. However, specific issues with the process that contribute to this cost have been identified that should make it profitable should they be addressed by different design or improved technology in the future.

When discussing the societal impacts of engineering, a recurring issue in prioritizing safety or profitability is consistently faced. This is often due to the perceived competition between the two focuses. However, the relationship between the two focuses is not always the case as a result, the STS portion of this thesis focuses on “How external factors such as policies, regulations, and public perception affect the manner in which safety and profits relate to each other?”. This is done to best determine how a competing belief, that safety and profits are symbiotic in nature, can be pushed to encourage both in engineering. A limited utilitarian perspective is taken on many of the different sources explored holding safety as highest priority but profitability is still a key factor not left out of consideration.

This section ultimately concludes that short term profits are the primary driver in the divide between safety and profitability. Information derived from previous case studies of industrial disasters and memos released by AIChE indicate that long term profit is difficult, if not impossible, when safety is not also kept in focus.