Utilization of Algae to Produce Biodiesel and Ethanol
(Technical Paper)

The Effect of Marketing of Prescription Drugs on the Health of the Patient
(STS Paper)

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

Almost every commercial segment in the United States of America is not without the presence of at least one advertisement for a prescription drug. Large pharmaceutical companies spent upwards of 30 billion dollars in 2016 on direct-to-consumer (DTC) advertising (Healy, 2019). This spending has been steadily increasing since the advent of the television and other media outlets, and its effect on the patient is paramount to whether these advertisements should continue or not.

In an age where almost all information about consumer products is transferred through positive advertisements, pharmaceutical manufacturers have adopted the same strategy. Commercials are often seen showing people with hope, newfound life, and happiness after being prescribed the marketed drug. These advertisements are aimed at select individuals who not only are afflicted with the certain disease or condition, but must be aware of it, and do not already have an effective treatment for it. The correlation between the rise of these advertisements with prescription rates and the prevalence of curable illnesses and conditions will be studied to assess the effect of the marketing on the overall health on the patient.

Unrelated to pharmaceuticals, but increasingly relevant in today's society, the world is currently experiencing a shift in power sources from nonrenewable greenhouse gas emitters, such as fossil fuels, to more sustainable sources, like wind, solar, and hydropower. One such source is biofuels, specifically algae, which can be used to create all manners of fuel such as ethanol, butanol, and diesel. Using algae, this technical project team will be using not only the oils that can be excreted, but also the cell matter to increase productivity and profitability of the algae facility.

Technical Topic – Utilization of Algae to Produce Biodiesel and Ethanol

In the United States today, bioethanol, primarily from corn, and biodiesel, primarily from soybean and rapeseed (canola) oil, are the most common biofuels in use, accounting for 16.1 billion gallons of ethanol (~10% of current motor fuel usage) and 1.83 billion gallons of biodiesel in 2018 (U.S. Energy Information Administration, 2019). Biofuels produced from algae represent a potential significant advancement to presently commercialized biofuels. Algae grow quickly, can be rich in oil, and is currently the only biofuel source technically capable of meeting more than half of U.S. fuel usage, as traditional biofuels require large amounts of land (Chisti, 2007). In addition to lower land usage, algal biofuels do not compete with food for land - a concern with current biofuels (Ajanovic, 2011) - since they can be grown in a wide variety of conditions and can be easily modified through genetic engineering for different strain characteristics(Gomiero, 2015; Hannon, Gimpel, Tran, Rasala, & Mayfield, 2010).

Several approaches have been developed to commercialize algal biodiesel, but there have been difficulties in algal cultivation that have hindered attempts to do so. In growing algae, open ponds and closed photobioreactors have been used. Open systems are cheaper, but are difficult to control, vulnerable to contamination, and can have issues with light penetration for photosynthesis (Saad, Dosoky, Zoromba, & Shafik, 2019). Closed systems give higher yields, are controllable, and save water, but are expensive and difficult to scale up. One company, Solazyme, attempted to overcome the issue of light penetration by engineering its algae to produce oil using a sugar substrate, allowing its algae to grow without sunlight in industrial fermenters (Biello, 2013). However, this approach is highly dependent on the price of sugar, and the use of sugar conflicts with avoiding competition with food and increases the environmental impact of the process. For photosynthetic algae, however, the limits of light penetration can cause low cell density in

cultivation, leading to lower production than theoretically possible, though still much higher than from typical agricultural sources (e.g., soybeans) (Dassey & Theegala, 2013; Li, Horsman, Wu, Lan, & Dubois-Calero, 2008). Low cell densities, combined with the small size of algal cells and the high water content of algal biomass, make harvesting and drying algae costly. While there are other costs associated with the production of biodiesel and other products, these costs are not unique to algae and are not as great a challenge as scaling up the growth of algae.

Ultimately, the high cost of cultivation and harvesting makes a biodiesel-only approach simply unfeasible. A fairly recent economic analysis of algal biodiesel production found a selling price of $8.52 per gallon was needed for an acceptable rate of return (Davis, Aden, & Pienkos, 2011). Given that the current average petroleum diesel price in the U.S. is $3.05 per gallon (U.S. Energy Information Administration, 2019), algal biodiesel is not economically competitive with fossil fuels on its own. Without a substantial increase in oil prices, or a breakthrough in algal cultivation techniques, this disparity in pricing for algal fuels will likely continue to be true, despite the necessity of replacing fossil fuels in the face of global climate change and fossil fuel depletion.

The proposed solution to this problem is the design and development of an integrated algal biorefinery to produce coproducts in addition to biodiesel. In doing so, the goal is to be able to sell algal biofuels at a lower cost than would otherwise be profitable if producing biofuels alone. While it is possible to produce and sell the higher value products by themselves, combined production with biofuels contributes to the ultimate goal of decreasing fossil fuel consumption.

To accomplish profitability of the facility, the chemical processes will be modeled using Aspen Plus to determine technical feasibility, and economic analyses will be performed on costs and outputs to determine economic feasibility. Data will be found from literature to design most unit operations of the process, including algal growth, algal composition, harvesting (i.e. flotation)

kinetics, transesterification kinetics, and kinetics for side-product processes like cellulose pretreatment and fermentation. Heat and mass transfer fundamentals, as well as Aspen Plus species and process-flow modeling, will be used for stream and unit operation design more generally.

STS Topic – The Effect of Marketing of Prescription Drugs on the Health of the Patient

DTC marketing is an aspect of the pharmaceutical industry which has grown rapidly over the past two decades, despite only being legal in the United States of America and New Zealand (Calfee, 2002). Expenditures on marketing in the medication industry have grown from $11.4 billion in 1996 to $29.9 billion in 2005 (Donohue, Cevasco, & Rosenthal, 2007), almost tripling in dollar amount. From 1997 to 2016, DTC advertising of specifically prescription drugs have increased from $1.3 billion to $6 billion (Schwartz & Woloshin, 2019). These increases in recent years are due to the Food and Drug Administration (FDA) regulation changes which occurred in 1997. In that year, the FDA relaxed rules on such advertising, allowing manufacturers to include the drug's name and its purpose in the advertisement, but now no longer needed to include additional safety information. Only the most important risks associated with the medication had to be included, causing manufacturers to advertise much more (Ling, Berndt, & Kyle, 2002; Wilkes, Bell, & Kravitz, 2000).

There is clearly a relationship between the rise in DTC spending and patient visits asking for prescription drugs, as shown in Figure 1 (Iizuka & Jin, 2005). This relationship is due to

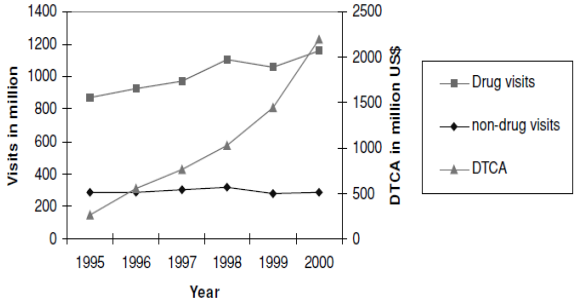

Figure 1: A positive correlation is shown between the amount of money spent on DTC advertising and the frequency of patients seeing a physician and asking for prescription drugs. Visits where no drugs are asked for are unchanged, proving the positive correlation of drug visits and DTC spending

patients asking for the medications as seen in the advertisements. According to Bell et al. in 1999, after conducting a survey of 329 people, 19 percent responded saying they asked for a drug specifically because of DTC advertising they saw (Bell, Kravitz, & Wilkes, 1999). An additional 35% claimed they sought information from a physician concerning a drug they had seen in advertising, further. DTC advertising typically primes the consumer by showing images of people getting hope and being happier, which incites a curious, imaginative state of mind. This mindset leads to people asking for more information from a physician and higher prescription rates (Foreman, Hsieh, & Grover, 2019), which is problematic because roughly just 25% of all advertisements include condition causes, risk factors, or prevalence, but 95% show emotional appeals to target the desire for hope in patients (Frosch, Krueger, Hornik, Cronholm, & Barg, 2007). This style of advertising causes patients to be uninformed about the drug but still request it anyway. Interestingly, the advertisements themselves rarely prompted physician visits on their own; according to one study, only 4% of those surveyed reported seeing their doctor exclusively because of DTC advertising (DeFrank et al., 2019).

The effects of DTC advertising are relatively universal for all prescription medications. Marketing improves the sale of a wide range of drugs, with positive correlations between advertising dollars and prescription rates for hyperlipidemia medication (Liu & Gupta, 2011), and erectile dysfunction (ED) medication (Ching, Hermosilla, & Liu, 2019). Within these prescription rates, certain drug brands are the most common – Lipitor for hyperlipidemia, Cialis or Viagra for ED – showing a "persistence" in physicians for the same drug (Janakiraman, Dutta, Sismeiro, & Stern, 2008). Further analysis will be done to assess if this persistence has been affected by increasing DTC advertising.

The STS framework to analyze this topic is actor-network-theory (ANT). ANT analyzes all of the possible actors and their effects in a network that disregards whether the actor is an object, technology, or a person (Cressman, 2009). In this complex system of physicians, patients, medication, technology, and marketing, ANT offers the most comprehensive analysis to determine the implications of each component. Unfortunately, ANT requires in-depth analysis and very thorough research. Comprehensive research will allow successful use of ANT in the complex system of prescription drug marketing.

Data is difficult to find about the rates of prescriptions, the medical effect these prescriptions had on the patient, and its correlation with DTC marketing. Analysis will be done on the relationship between the marketing of specific drugs to the prevalence of the disease or condition that it treats to determine the overall effect of marketing on the health of the patient.

Research Question and Methods

The question at hand is how exactly the marketing of prescription drugs affects the knowledge and overall health of the patient. This question will be answered through analysis of published studies, surveys, systematic reviews, and other related literature. All of the necessary information, in full or at least partially, is available either publicly or with access from the UVA library. Through careful and thorough analysis of this literature and combining all of the information into one document, a definitive conclusion will be made on the effects of prescription drugs on patient health. Emphasis will be placed on peer-reviewed systematic reviews and surveys of physicians. This question of the effect of prescription drug marketing on patient health is important because of the sheer volume of advertisements the average consumer is subjected to about something as serious as prescription drugs. This advertising is not the marketing of cars or video games; the products are medications which can either drastically improve someone's life or

cause further complications. A definitive conclusion would be especially beneficial in determining whether these advertisements should continue or cease.

Conclusion

DTC marketing of prescription drugs is big business for pharmaceutical companies, and it is paramount to determine if this is actually helping the general wellbeing of the population. It must be determined whether these advertisements are helping people learn about the appropriate drugs for their ailments, or simply misguiding consumers and only causing further harm. There is definitely a positive correlation between drug visits and DTC spending, but further research must be done to determine if this is having a positive effect on patients getting the appropriate medication they need.

Biofuels are the future of energy. They emit low amounts of net pollutants and save the damage done to the environment associated with mining fossil fuels. A shift to biofuels, particularly those sourced from algae, will allow fuel sources to be nearly carbon neutral and reduce the effects of global warming. The combination of using algal oil to create biodiesel and the cell matter to produce ethanol will ensure the profitability and success of the facility in a world dominated by fossil fuels.

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