



SOLAZYME: SYNTHETIC BIOLOGY COMPANY CLAIMED TO BE CAPABLE OF REPLACING PALM OIL STRUGGLES TO STAY AFLOAT

SUMMARY

Solazyme is a Californian company founded in 2003 with the aim of producing large quantities of algal oil for biofuels, cosmetics, nutrition, and other purposes. In the US, they have obtained permission to use four different genetically engineered strains of micro-algae for industrial production of algal oils. The US Food and Drug Administration (FDA) has permitted Solazyme to use algal oils made from one of the GE algae strains in food products. Solazyme portrays itself in the media as a company that can create an alternative to palm oil and thereby help save the orangutan.

This report examines the discrepancies between Solazyme's public claims about the potential of their algal oil production on the one hand and the serious technical and financial limitations that they have been facing on the other hand. Based on a close examination of Solazyme's financial reports to the US regulator (SEC), it is evident that Solazyme has consistently operated at a financial loss, with no evidence of any imminent breakthrough. Even worse for the company, they have been forced to close their main US production facility, leaving them with just one small US pilot facility and a large plant in Brazil which they have not so far managed to operate successfully.

The report further exposes a number of serious concerns associated with Solazyme and their interactions with US federal authorities/government:

Firstly, Solazyme obtained around \$22 million in grants from the US Department of Energy to develop algal biofuels. Yet they have never sold any commercial quantities of algal biofuels, though in 2009 they supplied a small quantity of biofuels to the Navy at an exorbitant cost of \$149 per gallon. All of their income in recent years has been derived from selling limited quantities of expensive niche products in other markets, mainly skin care products against wrinkles. It could thus be argued that the US Department of Energy has allowed biofuel subsidies to be used to develop completely unrelated products.

Secondly, the report looks at the, albeit very limited, information about Solazyme's genetically engineered algae which is publicly available. Most of this is contained in documents on the FDA website, related to the FDA granting the company permission to sell food products made with the aid of genetically engineered algae. The FDA has a very narrow remit when considering such applications: They do not look at the potentially very significant environmental risks

associated with any unintended escape of GE microorganisms, nor do they look at how credible a company's claims that they can keep such organisms confined really are. They simply look at potential public health impacts. Yet, as shown below, even within this narrow remit, the FDA appears to have been misled by different names used for one algae species into concluding that Solazyme's microalgae are safe for humans. In fact, the species engineered by Solazyme for use in food production happens to be linked to a rare but serious and potentially fatal disease in humans.

Finally, the report looks at the wider environmental risks associated with genetically engineered algae and with Solazyme's concept, which involves using algae fed on sugar and thus perpetuates the existing model of biofuel production reliant on large-scale monoculture plantations, which is associated with serious environmental impacts and indirect and direct greenhouses gas emissions from land use and land use change.

SOLAZYME: A SYNTHETIC BIOLOGY COMPANY STRUGGLING TO STAY AFLOAT

Back in 2011, Solazyme looked poised to become one of the most successful synthetic biology and advanced biofuel companies worldwide. Founded in 2003, the company had set out to develop first biofuels and then other oil-based products made from microalgae.

In May 2011, Solazyme started trading on the stock market. On the first day, they succeeded in selling 11 million shares, valued at \$18 each – exceeding their own expectations. [1] Investors clearly felt confident about Solazyme's future: According to a report by SoundView Research (a company providing research and advice for investors) [2] published shortly before Solazyme registered on the stock market, the company had “established joint ventures and partnerships with prominent companies”. Those included Honeywell UOP (a leading supplier for oil and gas refining), oil company Chevron, and agribusiness corporations Unilever and Bunge. They had “a large

patent portfolio with 125 patents issued or pending” (although just two of their patent applications had actually been granted at the time [3]). They had “reduced the estimated production cost of producing oil 10-fold over the past three years”, and they were “well along the commercialisation path”, having launched algae-based skin and personal care products, as well as nutritional products. Goldman Sachs and Morgan Stanley were leading Solazyme's public offering on the stock market. Overall, SoundView Research concluded: “We expect the company to achieve profitability by 2013”.

This prediction, it turned out, was wildly overoptimistic. By September 2015, Solazyme had accumulated a deficit of \$575.2 million, with over \$100 million in losses incurred during the first nine months of that year. [4] During those nine months, Solazyme had in fact sold nearly \$115 million worth of products made from algae – but they continued to incur losses of nearly \$79 million

from production. To cut future losses, Solazyme announced in October 2015 that they were pulling out of an agreement with Archer Daniel Midlands, and therefore closing down their main US production plant. [5] That leaves them with only a very small US pilot plant (in Peoria, Illinois) and a much larger one in São Paulo state in Brazil, albeit one which continues to experience technical problems and to operate at just a fraction of its capacity. Solazyme admitted in their October 2015 financial report that they did not expect the Brazilian plant to be fully commissioned ‘in the near future’. By December 2015, that plant was up to two years behind schedule. [6] Investors are clearly unimpressed: Solazyme's share price has fallen from \$18 in May 2011 to \$2.72 in December 2015. [7]

SOLAZYME'S ALGAL BUSINESS: AN OVERVIEW

Solazyme state on their website:

“Starting with microalgae, the world's original oil producer, Solazyme creates new, sustainable, high-performance products. These include renewable oils and powerhouse ingredients that serve as the foundation for healthier foods; better home, personal care and industrial products; and more sustainable fuels.”

In fact, 98% of profit made from Solazyme's product sales in the first 9 months of 2015 came from anti-ageing skincare products, which contain oil from microalgae. [8] Solazyme has a contract with Unilever for the supply of algal oil to use in some of Unilever's Lux

cosmetics and personal care products. However, Solazyme's recent financial statements suggest that any supplies to Unilever have been very small, if they have happened at all.

In 2014, Solazyme started selling other products, especially ones that contain whole algae rather than algal oil: A lubricant for oil drilling, and food products (algal protein and algal flour). [9] One of the main problems reported about Solazyme's production plant in Brazil (their only remaining commercial-scale plant) relates to ‘downstream processing’, i.e. to problems with extracting the oil from algae. Selling products from whole algae bypasses this challenge.

However, Solazyme has had little commercial success with whole algae products so far: Their revenues from products other than (oil-based) skin care fell by over 50% in the first nine months of 2015, compared to the same period the year before. [10]

Solazyme's efforts to sell their expensive new drilling fluid additive have clearly not been helped by low oil prices, but those are not the only problem: Far cheaper alternatives with similar properties have been reported. [11]

Solazyme has started producing algal oil for food products, [12] though in order to scale this up, they will have to

overcome their problems with extracting oil from algae in their Brazilian plant. They have amended their Joint Venture with agribusiness corporation Bunge (joint developers of Solazyme's plant in Brazil) to include food ingredients.

Although Solazyme has always presented itself as, in part, a biofuel company, they have never produced any algal oil for biofuels, except for the purpose of small-scale tests. Commercial biofuel sales would require large-scale production at competitive

prices and this seems to be well beyond Solazyme's capabilities.

MISLEADING CLAIMS ABOUT 'REPLACING PALM OIL'?

As Solazyme's reports to the US financial regulator (SEC) show, they have never been able to produce anything other than small quantities of expensive high value products. This has not stopped the company from promoting itself as a potential saviour of rainforests and orangutans through

the replacement of palm oil. An article listed on Solazyme's website claims "A California company has developed an alternative to palm oil to avoid the deforestation wiping out rare wildlife". [13] We have discovered 15 other articles with a similar message. People concerned about the destruction of

rainforests for palm oil are thus being misled about a 'solution' which, at least for now, simply does not exist.

DID THE US DEPARTMENT OF ENERGY SUBSIDISE SOLAZYME'S ANTI-WRINKLE SKIN CREAM WITH \$22 MILLION?

In September 2009, the US Department of Defense paid Solazyme \$223,500 for a very small quantity of algal oils for a biofuels test, at a cost of \$149 per gallon – 44 times the cost of petroleum-based fuels. [14]

Three months later, Solazyme was awarded a \$21.8 million grant from the US Department of Energy, for building an 'integrated biorefinery', [15] which served as a model for building Solazyme's larger subsequent plants in

Illinois (now being closed) and in Brazil. That pilot plant, based in Illinois, is still operating today.

Yet in spite of these generous subsidies for biofuel production, Solazyme's financial reports from 2014 or 2015 show no income from any sale of biofuels, nor do those reports mention any concrete plans to start producing them in 2016. Yet there has been no announcement requiring the company

to repay the grant. It appears that the grant, made to support Research and Development into 'advanced biofuels', has instead ended up aiding the production and sale of skin creams and lotions to prevent wrinkles.

SOLAZYME AND SYNTHETIC BIOLOGY

Solazyme used to describe itself as a "leader in algal synthetic biology", [16] although lately they have been publicly distancing from this description, claiming instead that they only use "traditional genetic engineering techniques". [17]

The independent consultancy report published just before Solazyme started trading on the stock market [18] was

entitled "Synthetic Nanobiology Comes of Age". Crunchbase, an online platform for investors trying to find out about start-up companies, describes Solazyme as "a synthetic biology company". [19] Solazyme has not publicly complained about the consultancy or Crunchbase describing them as a synthetic biology company.

However, in June 2014, 17 civil society groups called on Ecover (who describe themselves as manufacturing "ecologically sound cleaning products") and on their US subsidiary Method Products Inc. to cancel plans to use Solazyme's algal oils because of the serious risks associated with synthetic biology. [20] Ecover argued that the Solazyme's oils were not produced with synthetic biology, although they did

admit that they were made by genetically engineered algae. [21] This was in line with Solazyme claiming to only use “traditional genetic engineering”. [22]

Ecover's claims that Solazyme's oils were not derived from synthetic biology were based on their own very narrow definition of what synthetic biology is – one much narrower than the description used for example by the Secretariat of the Convention on Biology Diversity in their report on this topic. [23]

Ultimately, without access to Solazyme's closely guarded 'business secrets', it is impossible to know for sure whether Solazyme's algal oils are made using techniques that would generally be considered synthetic biology. Solazyme treat all details of

their genetic manipulation to algae as commercially sensitive and confidential – and they are not legally obliged to disclose them, with one exception: In the US, the Food and Drug Administration (FDA) requires public assessments for food products produced with the aid of genetically engineered microorganisms. Solazyme did in fact obtain an FDA permit to use oil derived from one strain of genetically engineered algae in food products. [24] This permit is discussed further below. Solazyme got permission from the Brazilian National Biosafety Technical Commission (CTNBio) to use this same GE algal strain in their Brazilian plant. [25]

However, Solazyme have clearly developed other strains of GE algae, too. The US Environmental Protection Agency has permitted them to use four

different strains (of a single species) of genetically engineered algae outside the food sector [26] and they have patented GE algae from altogether different genera than that used to produce algal oil for food. [27] In the US, no details of applications for the industrial use have to be published. [28]

Thus all that is known is that Solazyme uses more than one type of GE microalgae to produce algal oil. [i] And this itself involves serious if largely unknown and unassessed risks to the environment and potentially to public health.

A DUBIOUS RISK ASSESSMENT: DID THE FDA ALLOW THEMSELVES TO BE MISLED OVER KNOWN HEALTH RISKS LINKED TO ALGAL SPECIES GENETICALLY ENGINEERED BY SOLAZYME?

As shown above, published information is only available about one strain of GE algae used by Solazyme. It is the algae strain approved by the FDA for replacing oils and fats in a wide range of food products, [29] also approved by the Brazilian regulatory authority, CTNBio. The risk assessment required by the FDA only looked at potential human health impacts. The FDA does not require any assessment of the environmental risks of accidental release of GE algae, nor of the adequacy of the biosafety provisions used by the company.

Yet even within the narrow confines of the risk assessment's remit, the FDA's permitting decision raises serious concerns:

The FDA, it appears, overlooked the fact that the particular algal species used by Solazyme is associated with a rare but serious disease: Protothecosis.

Only a small number of microalgae are known to cause disease in humans and animals, and they are mainly confined to a small number of toxic algae associated with shellfish and certain reef fish. [30] So-called 'toxic algae' blooms are in fact cyanobacteria, which are quite different from algae. Just one disease is known to be caused by species of algae not linked to seafood consumption: Protothecosis. Protothecosis is caused by two algal species of the genus *Prototheca*: *P. zopfii* and *P. wickerhamii*.

Protothecosis is a rare disease which usually affects the skin but which can

attack internal organs and is potentially fatal. It is difficult to treat and does not appear to resolve without treatment. [31] Protothecosis is most likely to occur in people classed as 'immunocompromised', but those may simply be people taking steroid tablets, injections and creams, which are prescribed for a large number of conditions such as asthma. The disease also affects different mammals, especially dogs, who can develop meningitis as a result. [32]

The risk assessment report which Solazyme submitted to the FDA [33] refers to the algal species in question as *P. moriformis* but explains that most of the literature no longer recognises such a species and that it has been reclassified as *P. zopfii*, though it closely resembles *P. wickerhamii*. The

[i] Note that not all of Solazyme's products involve GE algae. Solazyme have not so far obtained permission for the use of whole GE algae outside their own plants, therefore those particular products must involve non-GE algae.

algal strain which Solazyme has genetically engineered thus clearly belongs to a species associated with the disease Protothecosis.

This obviously raises the question whether oils produced by a GE strain of such a pathogenic algal species could potentially lead to Protothecosis. The FDA, however, did not ask this question. Instead, they concluded that oils made by these algae were safe for human consumption on the basis that “Solazyme also discusses published case reports describing rare occurrences of algal infections in immunocompromised individuals, and notes that *P. moriformis* is not recognized in the scientific literature to have any associated pathogenicity.”

This appears to have been taken from the concluding chapter of the risk assessment, which stated: “To date, no case of human protothecosis documented in the literature has identified any strain of *P. moriformis* as

the causative agent”. It clearly contradicts what the in-depth discussion in the risk assessment which conceded: “Although *P. moriformis* has at times been considered a species...the assignment has generally not been accepted as valid.” The valid species name, as shown above, is associated with pathogenicity, contrary to what the concluding chapter and the FDA state.

The FDA’s second ‘safety’ argument is that the disease in question only affects ‘immunocompromised individuals’. The risk assessment submitted by Solazyme had played down the risks of Protothecosis by arguing that even common baker’s yeast can cause illness in people with reduced immunity. This is true – except that people at risk from a non-allergic disease caused by common yeasts are those already in intensive care – rather than people using common steroid medications, which is a key risk factor of Protothecosis.

As in all such risks assessments, Solazyme had been required to test their oils on rats. However, as the report admits, Protothecosis is known to affect humans, dogs and cats, but not rats. The tests could therefore give no information about the potential risks of Protothecosis linked to the algal oil.

The FDA thus clearly overlooked important details in the report and was misled by the concluding chapter, which blatantly contradicts what had been discussed before. As a result, they approved oil produced by a genetically engineered pathogenic algae species. The question whether this oil might make some people ill has simply not been credibly assessed.

WHAT ABOUT THE ENVIRONMENTAL RISKS?

Fuels from algae or from sugar cane?

Algal biofuels – or rather the idea of them, since none have ever been produced in commercial quantities – are widely promoted as an alternative to biofuels from crops and trees. Algae bioreactors or open ponds, after all, should not require fertile land. This, however, assumes that the algae get their energy from light. Solazyme’s algae, on the other hand, do not get their energy that way, but instead acquire energy from sugar. In their now closed plant in Iowa, the algae were fed on corn sugar sourced from GM corn monocultures. This remains the case in their small pilot plant in Illinois. In the new plant in Brazil, which is yet to be fully commissioned,

they are fed on cane sugar, provided by the multinational agribusiness corporation Bunge. Solazyme has published no information to indicate how much sugar – and thus land – is required per gallon of algal oil.

Both corn monocultures in the US and sugar cane plantations in Brazil are associated with serious environmental impacts. Sugar cane expansion in the Brazilian state of São Paulo, where Solazyme’s plant is located, has been shown to displace cattle ranching into the Amazon region, thus increasing Amazon deforestation. [34]

However, the prospect of Solazyme producing algal oil on a scale large enough to have any significant impact on land use for sugar cane seems

remote, given the technical and financial problems the company has been facing.

What might escaped GE algae do to the environment?

Microalgae play a vital role in regulating the global carbon and nutrient cycles and they are the foundation of the marine and freshwater food chain. Algae are thus fundamental to all life on earth. Yet the diversity of algal species, their functions and their interactions remain very poorly understood. It is thought that between one third and two thirds of marine algal species still remain to be identified. [35] Many algal species, are found across many different habitats and climate zones.

Prototheca species – one of which Solazyme has genetically engineered to make algal oil food ingredients – are found not just in fresh and marine waters, but also in bacterial infections of trees (slime flux), in grasses, food, soil, and even in the digestive systems of different mammals. [36]

As noted above, no ecological risk assessments are required for the use of GE algae (or other GE microorganisms) inside factories and refineries because it is assumed that those organisms will remain confined. This is a very dubious assumption. According to a report on Synthetic Biology published by the Secretariat of the (UN) Convention on Biological Diversity (CBD): [37]

“It is widely acknowledged among microbial biologists and ecologists that physical containment is never fail-proof... One of the conclusions that Schmidt and de Lorenzo (2012) draw from decades of research and use of recombinant DNA is that ‘it is naïve to think that engineered organisms have never escaped the laboratory. They often have, and massively.’”

There are many attempts to engineer GE microbes so that they cannot survive in nature, called ‘biological confinement’. As the CBD report explains, those methods are also far from foolproof. There are no indications that Solazyme are using biological confinement methods anyway - certainly their description of GE microalgal strain developed for food ingredients does not mention them. They appear to rely entirely on the fantasy of physical containment.

If physical containment cannot be fully guaranteed even within laboratories operated by molecular biologists, it will be far less reliable in an industrial refinery.

Virtually no studies have been carried out into the potential ecological impacts of GE algae and into the likelihood of them surviving and turning into alien invasive species. Genetic engineering is known to result in unintended mutations [38] as well as unintended changes in the characteristics of an organism which can result from an intended gene manipulation. This makes the potential

ecological consequences of escaped GE algae even less possible to predict.

It is known that the risk of any introduced species of microalgae becoming invasive increases significantly if ecosystems are already affected by other pressures, such as pollution, and that alien invasive microalgae can pose a serious threat to biodiversity, ecosystems, and fisheries. [39] The lack of transparency over Solazyme’s genetic engineering efforts coupled with a lack of studies about the ecological implications of an accidental release of GE algae raises the most serious questions, given how widespread the algal species in question are and how crucial a role microalgae play in regulating the earth’s atmosphere and life support systems.

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