Mud Pot Spirulina Cultivation in Haiti for Reduction of Malnutrition

Background

In Haiti, one in four children is chronically malnourished ("UNICEF: Children in Haiti"). A country plagued by disease, conflict and natural disasters, hunger is an issue becoming increasingly relevant. Rates of hunger are increasing, most affecting children, solutions, and innovation must arrive if such concerns are to be addressed. A potential answer to this problem is spirulina, an alga with astonishing nutritional value. It can be grown locally, with little water, no dirt, and low costs, and introduced in African countries such as the Democratic Republic of Congo (DRC). Results have been promising, showing that a mere one to two-gram dose can reduce malnutrition within a month of introduction. A large opportunity is missing as spirulina cultivation has never been fully introduced in South/Central America. Having a climate ranging from 22 degrees Celsius to 34, along with a persistent problem of soil erosion, spirulina makes for the perfect option; growing at around 26-36 degrees Celsius and without the need for soil. Haiti is facing a problem, and spirulina poses a sustainable, affordable, and effective solution.

There are many contributors to Haiti's crisis, starting with high population and political unrest. The population of Haiti is 12,257,000 with a 56.4% urban population and a 43.6% rural population (MacLeod et al.). The nation has official Republican/Democratic structures in place, yet many of them are still in the preliminary stages of development, as shown by the frequent bouts of institutional and political instability. Elections have been destabilized by ballot tampering as political unrest continues to stand.

Another contributing factor to Haiti's crisis is the climate. The country's unique features can create equally unusual problems, from soil erosion to natural disasters, making agriculture unstable. The region is made up of a broad high plateau in the east-central region and the Rocky Mountains interspersed with tiny river valleys and coastal lowlands. Regardless, roughly 65% of land in Haiti is being used for agricultural purposes. Farms in Haiti are numerous and small, averaging roughly 2.5 acres (´Haiti - Agriculture"Nations Encyclopedia,) Some of Haiti's major exports are cash crops of coffee and sugar in addition to various subsistence crops.

The average household size ranges from 4-5 family members, but statistics vary due to difficulty in collecting data (Badger). The standard diet for such a family may include beans, rice, sweet potatoes, bananas, plantains, corn (maize), cassava, and taro (a tropical tuber known as malanga in the area). However, a substantial proportion of Haitians struggle to achieve adequate nutrition due to a multitude of barriers, including cost. This issue becomes evident when one examines Haiti's unemployment rates - in 2022, they averaged 14.8% (Badger). For people who are unable to secure work, accessing food becomes increasingly difficult to pay. For those who can secure a job in the various prominent industries (mining, forestry, fishing, and agriculture), low pay and poverty are a common struggle, often leading to deficiencies in education and healthcare.

Many Haitians do not have access to education, with only 50% of children on average being able to attend some form of schooling (Badger). There are also strong barriers to receiving adequate healthcare, resulting in an average lifespan of 63, with a high prevalence of infant mortality and childhood stunting (Badger). Cost is one of the largest barriers to access to both education and healthcare for Haitians. With most schools run by for-profit organizations or religious institutions, schools are financially inaccessible

for many. Correspondingly, the Haitian healthcare system relies heavily on out-of-pocket payments, for some, simply seeking treatment for illness or disease is not possible. Some other barriers a family may face are distance (living far away from schools or a hospital), and crisis (conflict, natural disasters, etc.).

Malnutrition

The most relevant of barriers facing Haitians is food insecurity, which refers to the inability to consistently obtain enough safe and nutritious food for a healthy lifestyle. Nearly half of the Haitian population, or 4.35 million people (about twice the population of New Mexico), do not have enough to eat, and 1.4 million are experiencing emergency levels of food insecurity. Food insecurity can directly cause malnutrition, which is a rising issue in Haiti, particularly affecting children. A staggering one in four children in Haiti is suffering from chronic malnutrition ("UNICEF: Children in Haiti").

Unfortunately, as conflict and natural disasters remain present in Haiti, rates of malnutrition and childhood

stunting are not decreasing but are instead expected to rise. Malnourishment in children can cause a plethora of consequences: one of the most damning being, increased susceptibility to disease due to a weaker immune system. This response is especially relevant in Haiti as rates of Cholera rise with nearly half of cases affecting children ("UNICEF: Children in Haiti"). In correspondence, this is crucial because when a child is undernourished, they are not only more likely to get ill but to be unable to fight such illness. Additional consequences of malnutrition can include weight loss due to a depletion of fat and muscle matter, reduced cardiac muscle mass, negatively impacted immune function, and psychosocial effects (Saunders, J., & Smith).

Spirulina

To address this issue, mud-pot spirulina cultivation stands as a potential answer. One to three grams of spirulina a day for four to six weeks (about one and a half months) are enough to rehabilitate a malnourished child¨ (Birot). The panacea of spirulina has a composition of 5% water, 24% carbs, 8% fat, and 60% (51–71%) protein. It also contains B complex vitamins, gamma-linolenic acid (an important fatty acid), beta-carotene, vitamin E, magnesium, zinc, copper, iron, and selenium (Food Data Central). To show why spirulina has such a high potential as a malnutrition treatment in comparison to alternatives, Spirulina has the following advantages:

- 180% more calcium than whole-fat milk
- 100% more iron than spinach,
- 100% more beta-carotene than carrots
- 670% more protein than tofu
- 700% more phytonutrients than apples

In establishing the nutrition benefits of spirulina, sustainability, and accessibility must first be addressed. Typical methods of spirulina cultivation for treating malnutrition are generally large-scale and commercialized, while highly efficient environmental concerns related to the exportation and importation of such arise. Beyond that, the commercialized process also removes accessibility for the community, meaning to sustain such a method, the community at hand will always have to rely on outside sources. This is where the mud pot cultivation method comes into relevance. Before further elaboration of the benefits of this specific method can be concluded, the method itself must first be outlined.

Mud pot spirulina cultivation begins with water and a growth medium. In a country such as Haiti, this step alone poses a major challenge: how will these materials be obtained, and what will it cost? The answer is simple: salt water, which is free and accessible as Haiti is surrounded by the ocean. Saltwater

presents itself as both the water and growth medium all in one. However, when seawater is used alone, spirulina production can be impacted by a lack of available nutrients. This fact can be solved by the use of a digestate, which is a low-cost nutrient-rich substance that is produced by anaerobic digestion. It is made from indigestible material and dead microorganisms, increasing sustainably and bringing the price down. Diageste is extremely cost-effective as it costs only around ten cents a gallon (UC Davis Renewable Energy Anaerobic Digester (READ). The effect on the spirulina can be changed based on the ratio of digestate to seawater. When using a 5% digestate ratio, the highest amount of biomass production was observed (Giorgos Markou). When more than 5% digestate was used, increased rates of protein were observed due to the increased amount of variable nutrients in the growing spirulina. In comparison to what is needed to create biogas, supplemented saltwater provides a cost-effective and minimal solution. As to the effects saltwater would have on the growth vs freshwater, there are very minor effects in comparison to the benefits. Minor changes in pigment and a mild alteration in the lipid content along with increased carbohydrates can be observed but this is balanced out by the large increase in growth rates that is observed. A study shows that when spirulina was grown in saltwater with no additional nutrients it grew at a rate 52% greater than the control (Zietlow), which shows that although the girth of spirulina in saltwater can have drawbacks, the benefits far outweigh the cons.

The next step is to bury mud pots up to the top of the ground. These pots can be created by residents using the dried yellow mud from the country´s center plateau. Then, the saltwater along with spirulina culture is put into the pot and mixed. In the entire process of production and harvesting spirulina in Haiti, the spirulina culture is the only thing that needs to be imported, making it a reliable and sustainable solution as all other components and labor can be locally sourced, reducing the need to rely on outside forces in the

future. This mixture will need to be mixed 3-4 times a day as it cannot grow in stationary conditions, the pots also must be exposed to sunlight (Spirulina Farming).

Once ready to harvest, the spirulina can be gathered using simple and accessible cloth filtration. Finally, the spirulina is to be rinsed and dried, which it can be added to the traditional foods of the area (cassava paste, millet, etc.). This capacity for ease in consumption is significant as it allows for higher rates of consumption; simply put, people are more likely to eat what they are familiar with. It can also be taken in capsule form. In the case of drying being inaccessible, spirulina can be consumed raw (not dried and processed). As it is tasteless and odorless in this state, it does not need to be added to food and can be eaten alone.

Implementation

As previously discussed, the only practical cost associated with spirulina farming is the spirulina culture itself. The cost of growing one kilogram is roughly 5-7 Euros. Since only one gram per day is needed to see noteworthy results in children, this averages out to 1-2 cents per child per day, (Spirulina Farming - Akvopedia). To fund, this initial cost of physical materials initiatives related especially to spirulina cultivation could be utilized. An example of one such program is IIMSAM, an intergovernmental institute for the use of spirulina to combat malnutrition, this organization is registered under the UN Treaty (IIMSAM Spirulina Resource Center | Home.). Although their efforts have previously been targeted towards Africa, they remain as a potential source of funding among others. But, in discussing material cost, it is important to note that once the initial materials and education are provided to locals, this method becomes more and more cost effective as it progresses. This is due to the fact that in a similar fashion to how farmers save seeds from crops to plant the next season, residual spirulina can be saved from each batch to use to grow more supplement, rendering this solution to cost nearly nothing over time.

But, materials, without being able to get them into the hands of people who can (or have the education to) use them is a separate, more expensive and complicated matter. Quickly, it becomes clear that the largest barrier in this method is getting the knowledge to local Haitians. This is where local stakeholders become relevant. In getting the agricultural resources to communities several already existing projects and organizations can be referenced. One such example is Many Hands for Haiti; in the matter of agriculture they have implemented methods of spreading education. One is their Agronomy Technical School, which serves as a place to teach of more advanced and efficient agronomic methods (“Agriculture | Community Development"). Coursework specifically on growing spirulina could be easily implemented into these already existing programs.

A more widely used model in methods of livestock is family distribution systems. One such system as the Haiti Goat program works by providing the goats and teaching people how to raise them, and then they later receive a cut of the profit when the goat is sold, then receiving later down the road (“Goat Program – Hands and Hearts with Haiti "). In application to spirulina, the first supplies, (spirulina culture) would be given to locals free of charge, along with mentors or community members teaching how to use such supplies. Then, the families independently grow the spirulina, then when harvest time comes, a small portion of the spirulina would be given back to the original organization, Whom can then sell it to create the income needed for funding. What's more, as families or farmers learn how to grow spirulina, they can replace the original ¨imported¨ or foreign educators, creating a self-sufficient system that can operate without the need of outside systems.

Benefits

Benefits specific to the mud pot method are vast. For example, comparing pots to ponds enclosed with polythene or concrete, pots are easier to handle. If a pot breaks, it is simple to replace it and move it if needed. In addition, if there are no infections, contaminations, or other problems. Pot cultures can be kept alive for extended periods, increasing sustainability. As well, locals can produce more pots with little additional work. This ability for production to remain local decreases costs and environmental impacts associated with the exportation/importation of spirulina.

Spirulina cultivation via this method also produces a remarkably high yield. Three 35–40 liter (about half the volume of a mini fridge) earthen pots of spirulina are enough to produce two grams of high-quality spirulina powder each day (per person) (Spirulina Farming - Akvopedia), which is adequate to meet a person's daily needs for 100% vitamin A and 200% vitamin B-12.

This local method of production also creates a unique opportunity for local women's empowerment, beyond physical health. Growing spirulina using the mud-pot method does not require electric means, it

means it is an accessible job; both on the premise of location and resources. In addition, one does not need to be able to read to pursue this means of employment, further lending itself to women, who commonly have lower literacy rates than men in developing countries.

There are also specific benefits to the introduction of spirulina growth in Haiti. While spirulina-fueled nutrition programs are common in Africa, beyond minor case studies, nothing so has been implemented in Central America. However, given the conditions of Haiti, this presents an opportunity for a significant improvement. Up to one-third of Haiti's land may have deteriorated past recovery due to deforestation, which has resulted in significant soil erosion (MacLeod et al.). What this means for agriculture in Haiti is that the cultivation of food that requires soil (most of all plants), is often unstable and further contributes to food insecurity. This is where spirulina's unique quality of being algae becomes relevant; one does not need soil to grow it, making Haiti an ideal location for its cultivation. In addition, the optimal temperature for Spirulina cultivation is 26-32 Celsius, and Haiti's average temperature is 22C (winter) to 34C (summer), again, creating an optimal growing period of at least 4–6 months, for the months in which spirulina cannot be successfully grown, dried spirulina from the summer harvest can be utilized, creating a year-round solution.

To further support the potential success of this method, one can reference a multitude of prior case studies, all of which suggest promising results. A pilot study in the Democratic Republic of Congo concluded that ¨the rate of global acute malnutrition decreased from 30% before the Spirulina supplements to 20% at day 30¨(Matondo). In an intervention study completed in Karnataka, India, it was found that the prevalence of severe wasting decreased significantly, from 28.6% at baseline to 24.5% at the end line, or 4%. All three nutritional indicators—stunting, wasting, and underweight—showed improvements in the nutritional condition of the two male and female children (Kashyap). Finally, a French review in which thirty-one references were found, and for this evaluation, seven studies—three randomized controlled trials and four non-controlled trials—were kept. In every study, the effects of spirulina on weight were beneficial. Succeeding spirulina administration, other metrics such as arm circumference, height, albumin, protein, and hemoglobin improved in non-controlled trials (Halidou Doudou). All the later evidence stated shows that mud pot spirulina cultivation could significantly decrease rates of malnutrition and stunting in Haiti.

Haiti is facing a crisis, a situation in which one-fourth of its children are going hungry, and action must be taken. Local spirulina cultivation can be this action. It has many benefits to offer as a solution to malnutrition. With sound nutritional composition, its ability to empower locals by providing employment, its unique growing feature of not needing soil, and promising case studies, Spirulina offers a long-term, cost-effective, and sustainable solution to the issue that Haiti is experiencing,

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