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The Prospects of Using *Athrospira platensis* as a Malnutrition Treatment in Kenya

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Fall 2010

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ABSTRACT

The purpose of this research was to explore the current efforts using spirulina as a malnutrition treatment in Kenya. There are currently five spirulina cultivation sites that growing spirulina, four of which are located in the Nyanza Province. Their production and scope of advocacy efforts are limited. Some of the cultivation sites have a better quality control measures and strategic plan in place for expanding cultivation. Significant efforts need to be made to improve the scope of production and create links with nutrition experts in other non-governmental organizations and at the national level.

INTRODUCTION

Malnourishment is a state in which one does not consume an adequate balance of calories and protein for proper growth and maintenance or they are unable to fully utilize the food they eat due to illness. The FAO states that over a third of Kenya's population is undernourished, which was at least 10.8 million people in 2006. Undernourishment can be directly attributed to a lack of essential vitamins and minerals in the diet as well as the overall lack of access to food supplies. On average, the FAO estimates the undernourished population in Kenya has a daily deficit of 220 kcal/person/day (FAO, 2010). Two-thirds of the typical Kenyan diet is comprised of cereals, sugar, and vegetable oil but the diversity of the diet is improving to include more fruit, vegetables, and milk. The lack of diverse sources of calories and rampant undernutrition in Kenya are key causative factors to the high prevalence of Vitamin A deficiency and iron deficiency anemia in the country among other ailments (FAO, 2010)

The composition of one's diet is often determined by the sufficient availability and access to food, which is termed food security. The World Health Organization defines food security as existing "when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life". This definition includes "the physical and economic access to food that meets people's dietary needs as well as their food preferences" (WHO, Food Security 2010). Unfortunately, Maplecroft, a global impact assessment and monitoring organization, recently ranked Kenya as "High Risk" in The Food Security Risk Index of 2010 (Redfern, 2010). The UN Food and Agriculture Organisation states that the "stagnation of food production, an unfavourable economic environment and poverty are the major causes of food insecurity in the country" (FAO, Republic of Kenya Summary, 2010).¹ Many reports also criticize Kenya's ineffective government and failing infrastructure as a leading cause of food insecurity and malnutrition. ActionAid boldly stated in September, 2010 that "over the next 15 years more than two million Kenyans will still face severe hunger due to the disjointed efforts to address the challenge" (Nijiraini & Mwakio, 2010). Part of the "disjointed efforts" include the lack of government funding in the agriculture sector. Only 3.5% of the Kenyan national budget is allotted for agriculture. This is not abnormal on the African continent where most nations allocate less than five per cent of

national budgets to agriculture. Kenya recently signed the Comprehensive Africa Agriculture Development Programme which dedicates the country to increase this allocation by seven per cent over the next ten years but many are skeptical about the government's will to follow through (Njiraini & Mwakio, 2010). Without proper infrastructure agriculture production and distribution capacity drastically declines (Redfern, 2010).

Food insecurity and subsequent undernutrition in Kenya is a chronic problem. Even today “about 4 million Kenyans are in dire need of food aid” (Njiraini & Mwakio, 2010). Efforts seeking to alleviate malnourishment in Kenya often aim at immediate relief of micronutrient deficiencies and protein-energy caloric deficiencies. One such treatment includes the consumption of the blue-green bacteria *Arthrospira platensis*. Spirulina has recently joined the ranks as a malnutrition treatment for children with growing research supporting its efficacy in rapid recovery.

Given the high prevalence of malnutrition and the threat of long-term food insecurity in Kenya, it is important to develop sustainable solutions to treat malnutrition and micronutrient deficiencies. Much is known about the production process, distribution, administration of Ready-to-Use-Therapeutic Foods as a treatment for malnutrition. While the RUTF and other forms of food aid have been widely accepted amongst the international health aid organizations as well as malnourished patients, the high cost of production, import costs, and temporary treatment do not make these long-term solutions to malnutrition.

It is also important to note that these solutions often appear from international or global organizations rather than domestic. The insufficiency of reliable Kenyan infrastructure and effective government policies to adequately address malnutrition and food crises in the country is worrisome for the long-term health status of the population. On the same token, the climate disparities and contrasting ecological conditions amongst the different areas of Kenya play a key role in food insecurity. Effective domestic solutions to malnutrition in Kenya must consider these ecological challenges and limitations on the food distribution capacities within the country. I seek to understand such limitations and explore possibilities for domestic solutions.

More specifically, assuming the effectiveness of *Arthrospira platensis* as a malnutrition treatment, I propose to research the feasibility of using spirulina to alleviate malnutrition in Kenya. Spirulina is growing popularity because it is eco-friendly (in terms of land, water, and energy consumption), treats many ailments associated with malnourishment,

and has considerable potential for development as a small-scale crop for livelihood enhancement. Considerable progress has been made on the possibility of distributing spirulina in Kenya thanks to IIMSAM's "The Right to Food" Campaign and establishment of a production and advocacy center in Kisumu. However, the Dar Al Muamineem IIMSAM Center is limited in its capacity to take care of its patients and limited advocacy initiatives due to lack of adequate funding. Inadequate funding and other structural problems lead to insufficient production and ineffective marketing result into lack of greater public awareness.

The purpose of this research is to investigate what community, government, and international support is currently needed to produce and distribute spirulina on a wide-scale to the Kenyan population. This in essence demands a simultaneous investigation of the barriers that may inhibit the nation-wide distribution and utilization of spirulina. Along the way it is important to learn the requirements for cultivating spirulina (climate, facilities, financial, staff), the steps for spirulina production, the challenges for each step of spirulina production and distribution, and how these best practices were established. Best practices include quality control measures are in place at each production site including levels of micronutrients in spirulina, maintenance of water sanity, temperature, and pH. Other objectives of this research include to assess which parties and networks are involved in its production and distribution and describe the current uses and administration of spirulina to treat malnutrition and other ailments. Finally this research should suggest solutions to challenges and problems presented.

Literature Review

Spirulina is a cyanobacteria but it is often referred to as a blue-green algae even though it is not eukaryotic like algae. It obtains nutrients through photosynthesis (photosystem II & I, Calvin, and complete Krebs cycle). Spirulina is able to reduce nitrogen from atmosphere through specialized structures called heterocysts. It generally takes the form of tiny green filaments coiled in spirals of varying tightness and number, depending on the strain.

Many toxicological studies have proven that consumption of *Athrospira platensis* is safe to consume (Karkos P.D. et al, 2008). It belongs to the substances that are listed as the US Food and Drug Administration under the category Generally Recognized as Safe. It became famous after it was successfully used by NASA as dietary supplement for astronauts on space missions. It has also been used to treat Belo-Russian children who were harmed by the nuclear disaster as Chernobyl so that the radioisotopes were excreted (Loseva LP et al, 1993). It has been scientifically proven that Spirulina helps to treat anemia (Teakeuchi T., et al 1978), oral cancer (Schwartz, 1988), malnutrition (Fica V, 1984, Seshadri CV, 1993, Kulreshtha, et al 2008), protein-energy malnutrition (Bucaille P, 1980) eye problems because of its high beta-carotene content (Annapurna V, et al 1991), zinc deficiencies (Bhavisha R & Parula P, 2010), cholesterol related ailments(Nayaka N., et al, 1998), obesity (Becker E.W., et al 1986) stress and pollution related diseases by the virtue of its antioxidant molecules (Belay & Ota, 1993). For example, spirulina contains the SOD enzyme which neutralizes peroxide, a toxin that accumulates in the body. The chlorophyll is seen as a natural detoxifier as well.

Spirulina is high in Gamma-linolenic acid, an essential fatty acids that assists in the production of prostaglandins (help fight inflammation), and metabolize protein, carbohydrates, and fat (Nichols-BW & Wood-BJ, 1968). The high content of GLA implies spirulina can aid in weight loss because of these metabolic properties. GLA can reduce inflammation, assist nerve function, prevent allergic reactions or reduce their magnitude in some patients. Much of the GLA is not converted to arachidonic acid (AA) but rather to di-homo-GLA (DGLA). DGLA competes with AA and prevents the negative inflammatory effects that AA would otherwise cause in the body. Having adequate amounts of certain nutrients in the body, including magnesium, zinc, and vitamins C, B3, and B6, that can be found in *Arthrospira platensis*, helps to promote the conversion of GLA to DGLA rather than AA (Koskey, 2009),

Spirulina is high in other omega-6 fatty acids including palmitoleic, stearic, oleic, and linoleic, Alpha-linolenic acid (ALA), eicosapentaenoic acid (EPA), docosahexaenoic acid (DHA); all of which are helpful for the immune system function (Pascaud M, 1993). Another fatty acid present in spirulina, squalene, has been linked to increasing oxygen concentrations at the cellular level which aids in practically every cellular activity.

The phycocyanin that gives spirulina its blue pigment as well as the abundance of amino acids is useful in protein synthesis meaning it aids in the body's production of enzymes and antibodies among the many other molecules that use protein as a building block. The protein content of *spirulina* varies between 50% and 70% of its dry weight and because it lacks a cell wall 83-90% of this protein is digestible (Dillon & Phan, 1993).

There is a possible an explanation as to how spirulina boosts immunity for HIV/AIDS patients. Spirulina has extremely high levels of bioavailable polysaccharides. Some of these, like rhamnose and glycogen, attach to cell and HIV virus receptors inhibiting the virus from readily attaching to cells (Gastafson K, *et al* 1989). The polysaccharides have a synergistic effect with spirulina's nutrients and antioxidants, including phytosterols and tocotrienol, to boost immunity in HIV+ or - patients. It is worth noting that *spirulina* polysaccharides are believed to have a stimulating effect on DNA repair mechanisms (Pang, 1988). Spirulina contains vitamins: B12, B1, B2, B3, B9, B6, vitamin C, vitamin D, and vitamin E Out of all the vitamins, it is important to note the presence of Vitamin B₁₂ in spirulina, which is rare in photosynthetic materials, because majority of Kenyan are deficient in the vitamin. Micronutrient malnutrition efforts in the past two decades have heavily focused on vitamin A, iron deficiencies, and iodine. There have been significant supplement initiatives for these three micronutrients in Kenya. Spirulina is high in both vitamin A and iron so it can be useful in these efforts. However because of the high iron and protein content one must be careful administering spirulina to severely malnourished patients. Severely malnourished patients often have opportunistic infections and degraded red blood cells leaving free iron radicals in the blood. Bacteria feed off the iron and continue to thrive so administering iron at the beginning of a therapeutic treatment could actually threaten the life of the patient. Oedema patients often enlarged livers and the beginning of multi-organ failure so a large dose of complex proteins can be too hard for the patient's body to metabolize. When starting a malnutrition treatment the patients should

undergo an initial screening for infections, dehydration, and oedema then be started on a low-calorie supplement (Kenya National Guidelines & Kasiim, PC).

SETTING

The majority of research was conducted in Kisumu, a city located on the coast of Lake Victoria. Kisumu is the third largest city in Kenya with a population of over 350,000 in 2001. It is also the district headquarters of the Nyanza Province and Kisumu district. The town was founded in 1901 as a terminal of the Uganda Railway. The town was officially pronounced a “city” during centennial celebrations in 2001. The cash economy in Kisumu is mainly driven by fishing from Lake Victoria and agriculture. The fisherman population is almost exclusively male however “females constitute the majority of the labour force which in most cases is unskilled” (Kisumu District Strategic Plan 2005-2010, 5). The low school attendance contributes to this unskilled workforce because only 59 per cent of the population attends primary school and of that proportion only 25 per cent of students attend secondary school. This also means that any programs geared towards children in school will not meet over 40% of the school-aged child population.

In 1999, fifty-three per cent of the Kisumu district was population was described as “economically active” while the same percentage of the district population was also considered to be living in absolute poverty. A main cause of poverty in the area is “inadequate and unreliable rainfall pattern [that] has immensely affected agricultural activities, which is a source of livelihood of 90% of the [Kisumu district] population. On the other hand, during the rainy season, persistent flooding of the major rivers in the low lying areas destroy crops and causes water borne diseases for both human and livestock.” HIV/AIDS is disruption to the social and economic instability because the Kisumu district has one of the highest prevalence rates and mortality rates from AIDS in Kenya, standing at 28% (Kisumu District Strategic Plan 2005-2010, 5).

The people are mainly Luo with large population of Luhya, Kisii Kikuyu and Kalenjin ethnicities. The main languages spoken are Dholuo, Kiswahili, and English. Kisumu was the site of the first incidences of violence over the delayed announcement of the presidential results on December 29, 2007 and was one of the worst affected areas by post-election violence in early 2008 (Mathenge, 2010). The post-election violence led to a displacement of local 180,000 people (many of whom were small holdings owners and farmers), shortage of maize production, and interruption in the economic base (International Medical Corps, 2008). The clash arising from politically motivated differences between Kikuyu and Luo ethnicities wrecked havoc on the industrial and agriculture sector leading to

an even higher unemployment and malnutrition rates in the area. Recently, a study estimated that 33.5% of HIV/AIDS children in the Nyanza province of Kenya are malnourished, and even this prevalence is likely an underestimate (Berger, 2009). According to the 2008 Kenya Demographic and Health Survey Nyanza Province 31% of residents are malnourished. For the age group of children under the age of five, 10.6% are underweight and 31% have stunted growth (Rael, PC). By October 2008, the general disruption in agriculture throughout the Rift Valley of western Kenya, the breadbasket of the country, President Kibaki had declared a national food emergency in Kenya(IRC, 2009). As a timely response to the food crisis, the Dar Al Muamineen IIMSAM Centre was established in Kisumu in April 2009. Kisumu is an ideal area for the production of spirulina due to the area's consistently warm weather and agriculture background.

METHODOLOGY

My research was conducted at the Dar Al Muamineem Centre as well as at the production site their partner in Kogelo. Significant amount of baseline information about spirulina production in Kenya was gathered from the Dar Al Muamineem Centre twenty-seven employees. These employees include the Administration Director Mr. Frederick Lwamba, Technical Director Fundi, Principal Adviser on the Institutional Advancement in Africa to the Director General Ms. Elhaan Egeh, seven spirulina maintenance employees, Camp Maradona Executive Director Charles Ochome, clinic officer Fred Owino and Spirulina farm officers David Okonda and Maurice Kamale.

I conducted informal interviews with the participants in the center's feeding programs to get personal testimonies on the effects of spirulina. No parameter requirements--gender or age or any other demographic--were set as a way to evaluate the variety of people involved in the feeding program. The Dar Al Muamineem basic clinic data log was a good source of data on the demographic data on the feeding program participants, number of participants, their anthropometric measurements throughout the feeding program for the past two years. I visited IIMSAM partner schools and organizations in Kisumu that receive spirulina supplement supplies as part of their advocacy and outreach efforts.

Significant amount of time was spent traveling to other spirulina cultivation sites including: Masinde Muliro University working with Galaxy youth group, Jasq Paal's Dunga farm, and Kisumu Kids Empowerment Organization production in Milimani, Great Lakes University, and Aviva office in Nairobi. I interviewed the Professor Karwitha Kiugu, a Kenya Agriculture Research Institute (KARI) board member and founder of Aviva, whom I visited IIMSAM on January 2010. I investigated the status of the drafted Memorandum of Understanding between KARI and IIMSAM, the parameters of the MOU, and the future role of KARI in spirulina production and distribution.

I interviewed government officials and agricultural researchers about their knowledge on spirulina and the current government initiatives, if any, encouraging the production and distribution of spirulina country-wide. Such government officials in Nairobi included those in the Gender and Home Economics Subdivision under the Ministry of Agriculture, Ministry of Medical Services. Other government officials at the provincial level of Nyanza and located in Kisumu included those in Ministry of Health Nutrition Division, Gender and Home Economics subdivision under the Ministry of Agriculture.

I interviewed medical researchers to discuss their malnutrition research in Kenya to gain perspective on the opportunities and difficulties for scientific research in Kenya on the effects of spirulina consumption. Researchers included doctors at Kenya Medical Research Institute and University of Nairobi Medical School, and a micronutrient expert at the Center for Public Health Research in Nairobi.

I interviewed other nonprofit organizations to learn about their perspectives on the future role of spirulina alongside RUTF and food aid in treating malnutrition. This included the Oxfam Arid and Semi-Arid Lands Food Security Coordinator in Nairobi and Oxfam's Livelihood Coordinator in Lodwar, Turkana. I interviewed World Vision and International Rescue Committee Nutrition coordinators in Lodwar.

RESULTS

Arthrospira plantensis, commonly referred to as spirulina, is a cyanobacteria that grows in water with specific climatic conditions. As the name cyanobacteria suggests, spirulina has a deep blue-green color that diffuses in water. It naturally grows in freshwater lakes with a high alkalinity and saline content (Fogg, 1978). While *Arthrospira platensis* is found in various locations Africa, Asia, and South America the volcanic lakes in the Rift Valley Kenya--such Lake Nakuru, Elementaita, Bogoria--are some of the largest natural supplies in the world. Large flocks of flamingoes are the main consumers of spirulina in these lakes. Recently, there have been increased efforts in Kenya and worldwide to artificially cultivate and produce spirulina as a health food.

For optimal growing conditions, the water needs to have an alkaline pH and saline content. As a bacteria spirulina is a photosynthetic organism that grows best with maximal sun exposure. Spirulina tends to float on the water surface for greater sun exposure and warmer temperatures. In fact spirulina grows best in warm water temperature. In artificial cultivation ponds, the depth of the water should be shallow and the ponds broad in order to maximize sun exposure and minimize the difference in water temperature. Artificial spirulina ponds also require agitation on a regular basis in order to minimize the temperature gradient between the lower depths and water surface temperatures. Agitation is also necessary to encourage replication of the cyanobacteria. Once the concentration of spirulina is at a certain level, which is most easily identified by the lack of visibility in the water, it is ready to be harvested.

The microscopic aqueous cyanobacteria is harvested by extracting spirulina through a series a sieves and progressively finer filters. The purpose of filtration is to increase the concentration of this raw spirulina by removing as much water as possible until it reaches a paste-like consistency. This form is referred to as the “wet” form and can be immediately consumed alone or mixed with food. The wet form can be preserved by drying for a longer shelf life. After drying, the spirulina conglomerates are further processed by grinding it into a fine powder. The powder form is commonly referred to as the “dry” form. The spirulina powder can be compacted into tablet or capsule form, eaten raw, or combined with food. When combining the wet or dry form with any food the food will take on the same deep green color. While this change in color may be unsightly, spirulina is largely tasteless and

does not affect the original taste of the food. However, spirulina does have a distinct yet mild mold-like aroma. The smell can be quite pungent if large quantities of spirulina are stored in an small, enclosed area.

Spirulina was discovered in Lake Chad in Nigeria and lakes of Mexico by French scientist Hubert Durand-Chastel in 1968. However residents of Lake Chad had depended on spirulina from the lake as a food source for generations. Researchers ranging from microbiologists, nutritionists, and health professionals have evaluated the properties of spirulina, conditions for its growth, and nutritional values. Since the United Nations declared spirulina as a “food for the future” in 1974 at UN World Food Conference there has been immense interest in using spirulina to treat various ailments and malnutrition in developing countries as well improve general health. Dr. Ripley Fox was an instrumental researcher that pioneered initiatives to grow spirulina at a local level. There are production sites at either commercial or local levels around the world in countries such as France, Switzerland, Thailand, Malaysia, Vietnam, China, India, Turkey, Niger, Mali, Burkina Faso, Cameroun, Central African Republic, Madagascar, and most recently Kenya.

Spirulina was originally brought to Kenya in late 2006 by a Dutch woman Els Mulder who ran the non-governmental organization Kisumu Kids Empowerment Organization (KKEO) and children’s home for disabled children in Tom Mboya Estate in Kisumu. She originally learned of spirulina through while visiting a friend in Democratic Republic of Congo. Her friend was running a children’s home similar to Els’s while also using spirulina to “help them” and treat their wounds, bedsores, and other ailments. Impressed with the visible impact of spirulina, Els became interested in the production of spirulina. After learning the basics of its cultivation Els returned to Kisumu with a five liter can of spirulina with the intention of administering to the children at KKEO.

After a failed attempt to successfully cultivate spirulina she requested a spirulina expert from DRC, Fundi, come visit her production site in Kisumu for further assistance. Fundi came to Kisumu on a consultation basis in late 2007. He helped construct polythene lined basins on Els’ property in Tom Mboya, started cultivating spirulina from a sample he obtained from the production in DRC, and gave further training to Els and her staff. However shortly after he left again the spirulina production failed.

Eventually Els negotiated for Fundi to be employed at KKEO as the technical director of spirulina production. By 2008, Kisumu Kids Empowerment Organization was cultivating

spirulina as the “first proper production site in Kenya” (Lwamba, PC). The spirulina was used as a food supplement for the children as well as a treatment for their wounds and bedsores.

In January 2009, Els traveled to New York City and United Nations Headquarters to formalize a Memorandum Of Understanding (MOU) between Kisumu Kids Empowerment Organization (KKEO) and Intergovernmental Institution for the use of Micro-Algae Spirulina Against Malnutrition (IIMSAM). In 2003, the Intergovernmental Institution for the use of Micro-algae Spirulina Against Malnutrition (IIMSAM) had been established as a permanent observer of the United Nations Economic and Social Council (ECOSOC) (IIMSAM.org, 2006). It already had partners in ten countries: Italy, Benin, Cameroon, Democratic Republic of Congo, Equatorial Guinea, Gambia, Guinea, Sao Tome and Principe and Somalia.

Formalizing this relationship facilitated the visit of the Secretary General and other staff IIMSAM Executive Office to Kisumu in April 2009. That month a treaty was signed to recognize that IIMSAM would purchase a property and own the organization while KKEO would be incorporated as a partner. A large plot was purchased in Kongony outside of Kisumu town named the Dar Al-Muamineem IIMSAM Centre. The center officially opened on April 26th 2009 and they began cultivating spirulina in four polythene basins with a total capacity of 180m². However, differences over administration with Els and formal operations with KKEO cause a split between KKEO and IIMSAM. The administration director Mr. Frederick Lwamba and technical director Fundi chose to stay with IIMSAM as well as all of Els’ spirulina cultivation staff. On May 25th of 2009 Dar Al-Muamineem IIMSAM Center was given full diplomatic recognition by Kenya through a treaty with the Kenyan government. The signing of the treaty also allowed for Kenya to become the eleventh official member of the IIMSAM treaty mandate and expanded the Dar Al-Muamineem Kisumu Center as the IIMSAM East and Central Africa Spirulina Programme.

Within the first few months of its official opening the Dar Al-Muamineem Center conducted a series of trainings on spirulina for community members and interested parties. Charles Ochome, who had joined the Kenya IIMSAM staff in February of 2009 to run the Camp Maradona children’s football organization, was one of the trainees. He quickly established his own production site at his home in Kogelo. By March he had 75m² worth of cultivation space that was a replica of the Kongony IIMSAM open basin set-up. Ochome’s basins are considered an extension of IIMSAM’s production. He currently has approximately

90m² of space growing spirulina. A graduate student at Masinde Muliro University Paul attended the trainings and through a partnership between the university and Galaxy Youth Group started a production site in Kakamega in early 2010. They currently have two greenhouses made of opaque plastic that contain a total 9 basins made of wood supports and plastic lining measuring 20m by 2m for a total of 360m². Around the same time a Indian Kenyan native Jasq Paal started a production site in Dunga after attending IIMSAM trainings and conducting his own research on spirulina cultivation. He has 15 concrete basins for a total of 480m² cultivation space. While IIMSAM refers to Kakamega and Dunga cultivation sites as their “partners” these cultivators are thankful for the initial training but do not see themselves as affiliated with the organization because they receive no advice or monetary support from IIMSAM. In fact, Dunga Spirulina considers itself to be the only truly successful production site in Nyanza Province with a reliable daily output. Other groups, such as a Christian Women’s group and Great Lakes University in Kisumu, have attempted to cultivate spirulina after attending the IIMSAM trainings but were unsuccessful.

Besides these four currently successful cultivation sites, Els continues to cultivate spirulina in Milimani close to her former Tom Mboya Estate cultivation site. In October 2010 received a photobioreactor from Soley Biotechnology Institute through a partial donation of its expense in order to cultivate spirulina in a completely self-contained, enclosed system. The photobioreactor reportedly contains 40,000 L of water. Els estimates that daily harvesting will start in January 2011. A board member of Kenya Agricultural Research Institute Professor Karwitha Kiugu has a fledgling health food company Aviva and started cultivating spirulina in 2009 near Mount Meru as one of the twenty-five products for sale. Professor Karwitha was aware of spirulina’s health benefits after conducting research on the cyanobacteria in the Netherlands in 1981. This research focused on the effects of spirulina-supplemented feed on broiler chickens. She returned to the prospect of using spirulina as a health product when she developed the idea of creating her company Aviva in 2005. She currently cultivates spirulina in two concrete basins and two polythene basins for a total of 120m² of space. While she visited IIMSAM’s production site in Kisumu in 2009 she was already very familiar with spirulina cultivation and did not attend their trainings or rely on their technical expertise. In total there are six locations of spirulina cultivation, five of which are Nyanza Province. See the table below for a description of where these are located and who is overseeing its production.

Table 1: Spirulina cultivators in Kenya

Location in Kenya	Supervisor	Brand name or Organization	Start of cultivation
Milimani/Tom Mboya, Kisumu	Els Mulder	Kisumu Kids Empowerment Organization (KKEO)	2006
Kongony, Kisumu	F. Lwamba/Fundi	Dar Al-Muamineem IIMSAM	January 2009
Kakamega	Edgar (Paul & Prof. Sigot)	Galaxy Youth Group / Masinde Muliro University	2010
Dunga, Kisumu	JasqPaal	Dunga Spirulina	late 2009
Mt. Meru	Karwitha Kiugu	Aviva	2010

The cultivation sites listed above are the ones currently known. The time of initial cultivation were reported by the supervisor. Others may be starting independently in Kenya but have no relationship or communication with these producers. Antenna Technology is said to be in the works of starting a spirulina program in Mombasa, Kenya

DISCUSSION & ANALYSIS

Cultivation Requirements

All of the cultivators in Kenya agree that spirulina takes a certain degree of care in order to meet the specific conditions necessary for it to grow properly. Some seem to downplay the degree of difficulty to maintain the requirements or are not as meticulous in cultivation maintenance. However those that have taken the cultivation seriously have had the greatest success in production. In general, cultivators agree there are three areas that must be monitored during spirulina cultivation: water, temperature, and agitation.

The water requirements are the most important because spirulina grows in ponds and can survive only in particular environments. Water sanitation, salinity, pH, depth, and temperature must be monitored and controlled at all times. Spirulina does not have a cell wall therefore it easily absorbs any chemicals, including heavy metals, that are in the water through its porous cell membrane. This is useful if one chooses to fortify spirulina with minerals, such as selenium, by adding it to the water but dangerous if the water source is not “clean”. There are microbial contaminants that can cause harm human health. Many of these cannot survive in the same water as spirulina but the permeability of spirulina cells urge caution for water supplies. Water salinity and pH is controlled by adding a range of at least eight chemicals and minerals including: sodium bicarbonate, magnesium sulfate, citric acid, urea, ammonium phosphate, ferrous sulfate, sodium chloride, potassium. They vary in ratio according to the needs of the water composition. All of the cultivation sites use these chemicals however more sophisticated production can add 24 or even up to 52 chemicals and minerals to the water (Edgar, PC).

These chemicals are also vital for maintaining the proper pH of the water. All cultivators agree that it is critical to maintain an alkaline pH with the optimal range between 8.3 to 11.5. Spirulina is one of the few bacteria that can survive in such a high pH. *Chorella*, another cyanobacteria with similar properties, can survive in this pH and often co-habitats with spirulina. Maintaining such a high pH prevents contamination from other harmful bacteria such as *E.coli* and intestinal parasites such as schistosomiasis and giardia. This is important because except for Kakamega and Milimani sites all of the cultivation sites use open-air basins to grow spirulina. Dunga cultivation site is within 100m of Lake Victoria, which is known to be a polluted from factories and water-borne diseases have increased within the past decade (TED 2010). Earlier in 2010, the Dunga basins were contaminated with

Microcystis aeruginosa, which produced a potent hepatotoxin called microcystins. The supervisor had to restart the entire cultivation site with a clean sample after he built walls surrounding his property. While he has a minor suspicion that someone tried to sabotage his efforts by contaminating the basins he believes that not maintaining a pH of 11 allowed for the contamination there.

However he also acknowledges that maintaining such a high pH can have detrimental effects on production rates because the growth curve sharply declines after a pH of 11. Large calm pools of water give rise to the concern of these spirulina basins becoming breeding grounds for *Anopheles* mosquitos, which are the vector for malaria. This would be a serious concern in Nyanza Province where malaria has a high prevalence rate of 9.6% and is responsible for 4000 cases and 89 deaths in 2009 (TravelHealth, 2010). However the high pH does not allow for mosquitos or their eggs to survive. It reportedly causes the male mosquitos sperm to kill the female mosquito; although the scientific validity of this explanation is questionable (David, PC).

The cultivators in Kenya differ on which end of the pH range they prefer for their spirulina cultivation. For example, IIMSAM in Kisumu and Kogelo keep the pH within 9.4 and 9.6 explaining that it is high enough to prevent contamination, allows for sufficient production of spirulina, and a higher pH would require more chemical inputs to maintain and is not necessary. Milimani production has an automatic pH monitoring system that maintains a consistent pH of 10. Kakamega, Dunga, and Aviva cultivation sites maintain a pH of 11. They all agreed that this high pH encourages a high rate of production and guarantees no contamination from external sources. In general, if the pH is too basic citric acid is added. If the pH is too acidic ammonia phosphate and sodium bicarbonate are the first chemicals added to remedy this problem (David, PC). All of the cultivators, except for Aviva's production, agreed that the chemicals were the greatest expense in the cultivation. Aviva's greatest expense is the cost of commercial processing, which will be discussed later.

All of the cultivators agree that a water depth of twenty to twenty-five centimeters is ideal for spirulina cultivation. This water level is recommended in order for all depths of the water to receive adequate sunlight exposure and have a minimal temperature gradient from the water surface to the deepest point. Water is lost through evaporation and also during harvesting when the spirulina is extracted from the basins. It is necessary to maintain a balance between water levels and chemical content so that the chemical concentration does

not become toxic. Therefore, a ready supply of water is also necessary. In fact, IIMSAM-Kogelo, Dunga, and Aviva production sites have all invested in piped water to the site to ensure against water shortage problems. Cultivation sites, such as Kakamega and IIMSAM-Kisumu, that do not have regular access and a steady supply of water have had difficulties with low production levels. Currently, as of November, 2010, only four out of nine basins at the Kakamega production site had sufficient depth of water. When this significant drop in water level occurs it is suggested that one combine the different ponds into one in order to prevent the spirulina from dying. This can be a laborious, time-consuming task transporting the spirulina-filled water from one basin to another basin bucket by bucket-full. The supervisor in Kakamega was using the Masinde Muliro University water delivery service to truck water to the site and to replenish the water levels. IIMSAM-Kisumu often relies on rainfall to replenish the water levels in the basins. While Nyanza Province is not part of the arid and semi-arid land of Kenya, rain patterns there are notorious for being unpredictable and often inadequate. As mentioned earlier, it is also important to ensure that water supplies do not contain heavy metals. Strict sanitation may not be necessary if a high pH is maintained.

Water temperature is also vital for spirulina to grow because it prefers warmer temperatures. The optimal water temperature range is 35 to 37°C but can grow in temperatures as low as 20°C (Jasq Paal, David, Fundi, Edgar, PC). However if the temperature reaches over 40°C spirulina proteins denature and the entire pool of bacteria can die within hours (Jasq Paal, PC). At the other end of the scale, if the temperature reaches 15°C or below spirulina quickly dies. Basic spirulina production is done in outdoor, open air facilities so that cost of maintaining these temperatures is minimal if any cost at all. For that reason the air temperature is important, including at night. Kisumu and the Nyanza province is an ideal location for spirulina production because the average temperature year-round ranges from 18 to 29°C. Other areas, such as Central and Nairobi Province can have temperatures dip as low as 6°C, which is a risk for spirulina production. The Kakamega cultivation site uses a greenhouse to maintain a warm air temperature throughout the day and retain heat at night. However, the basins are dug into the ground as to keep the water temperature from getting too hot. The IIMSAM centers in Kisumu and Kogelo use yellow plastic sheets to cover the spirulina basins during the heat of the afternoon to prevent the water temperature from getting too high. Jasq Paal, on the other hand, found these yellow

plastic sheets to be unnecessary for temperature control. In fact he found that covering it reduced the sun exposure needed for photosynthesis and blocked the blue and green rays of the UV spectrum that spirulina needs the most (Jasq Paal, PC).

Agitating the water is the last main component necessary for spirulina cultivation. In natural settings, animals that feed on spirulina and the natural flow of water stir the spirulina colonies. Agitation is necessary to aerate the bacteria increasing the oxygen and carbon dioxide flow through the depths of the ponds and release the build-up of gases as a by-product of photosynthesis (David, PC). Agitating also disturbs the clumps of spirulina in such a way that breaks the long spirals of spirulina in such a way that encourages further replication and growth of spirulina strands. Agitating the water should be done in such a way that rotates the top layer of spirulina lower in the water and brings the deeper spirulina to the surface to circulate the temperature and ensure that all of the spirulina receives direct sunlight. It should also be done slowly and carefully as to not rupture the bacteria's cell membrane. The simplest way to agitate the water is to use a brush attached to a pole moving it in a circular motion down the basin; this method is used at the IIMSAM centers, Kakamega, and Dunga sites. Aviva uses a hand-powered turn paddle to circulate the water. During the daylight hours, IIMSAM-Kisumu recommends that the water be agitated every half hour to two hours. However, the technical employee at IIMSAM-Kogelo center says he was taught to agitate the water every three to four hours. Kakamega employees agitate the water every two hours. Jasq Paal on the other hand is very particular that his ponds be agitated every thirty minutes at the longest interval but even up to every 15 minutes. He claims that if the water is allowed to sit in the sun for two hours the surface-spirulina can easily die. The consensus is "often" but the measurement of "often" is ambiguous. Circulation is not necessary at night when there is no sunlight. Letting the water rest also gives the spirulina a chance to grow without disruption.

The photobioreactor used in Milimani is a self-contained system that does not need additional inputs, such as chemicals or water, after initial set-up. The temperature is controlled and water loss is minimized because the whole system is enclosed. Saline and pH content of the water is automatically controlled. The amount of sun exposure and intensity of spirulina in four large glass pyramids with a depth of approximately fifteen centimeters is monitored as well. The system circulates the water from these glass pyramids to a dark tank that resembles a large water bladder made of plastic. The glass pyramids are also injected

with carbon dioxide and oxygen bubbles at regular intervals. At night the glass pyramids are backlit to series of UV lights to have a continual twenty-four hour production process. All aspects of the spirulina production is automatically controlled and the enclosed design prevents from any contamination or human error.

Other than the bioreactor none of the cultivation facilities in Kenya use sophisticated equipment. The spirulina is grown in basins made of concrete or plastic sheets with wooden supports. The basins made out of plastic are the cheapest to construct at around 22 USD per square meter. However the liners need to be replaced about every six months. The maintenance of the basins and cultivation requirements are maintained by technical employees. It is recommended that there be one staff member per 100 square meters of spirulina pond (Antenna Techonology, 2010).

HARVEST AND PRESERVATION

Spirulina is ready for harvesting when the concentration is high enough. The concentration is measured using a transparency index that indicates the bacterial abundance. Using a Secchi disk, which is a graduated ruler with a white disk attached at the end. The white disk has a five centimeter radius. The Secchi disk is slowly submerged in the water until the white is no longer visible. This depth is then read on the graduated ruler. Essentially the question is “how deep must the Secchi disk be in order for it to disappear in the green water?” When the depth reaches two to three centimeters the spirulina concentration is high enough to be harvested.

Harvesting is best done early in the morning after the spirulina has been left overnight undisturbed to multiply in quantity and lengthen each strand. In essence, the biomass rapidly increases over night after regular agitation from the previous day. Spirulina is the only food crop that can be harvested on a daily basis year-round. This continual output is an impressive and unique quality for the bacteria.

Harvesting spirulina is a simple process that merely requires that the bacteria be extracted from the water. First the water is poured through a sieve in order to remove dirt and large debris that may have accumulated in the open-air basin. If the spirulina is at a high enough concentration or the spirals are so long that it accumulates in thick clumps the spirulina can be extracted with this sieve leaving the smaller spirulina strands in the water. This is the case at the Kakamega cultivation center. Otherwise the spirulina is strained through filters that progressively reach a hole size of thirty to forty microns. These sheets are

purchased from a Swedish production company charging 70,000/= per sheet that is approximately one square meter but then costs an additional 30,000/= to be imported through Kenyan customs. These filters can last up to year if properly cared for. The filter can be as small as five microns. At this point the water dropping below the filter should be clear indicating that every strand of spirulina is remaining on the filter paper. It is best to filter the spirulina over the basins it is extracted from in order to minimize water and chemical loss. The spirulina would have a goo-like texture.

From there the spirulina is squeezed inside the filter screens to extract as much water as possible without being too harsh in pressure on the fragile bacteria. This is the “wet” form that must be consumed within days in order to prevent loss of nutrients. It can be kept fresh by covering it and placing it in the refrigerator. This spirulina paste is then placed on mesh racks for drying. To maximize surface area and decrease time needed to adequately dry the spirulina it is squeezed into lines. One can use a condiment bottle or simply a bag with a hole at one end in order to squeeze it onto the racks. The IIMSAM-Kogelo center often skips this process and chooses to spread the spirulina as a paste-cake on the rack as a way to save time. It can be dried in the shade or in a solar dryer but never in the direct sun. Exposing the spirulina to direct sunlight at this stage will bleach the nutrients and denature the proteins that make spirulina so high in nutrients. In the shade it takes the spirulina approximately four hours to dry. Drying spirulina in a solar dryer is the recommended method as it allows for maximal heat without overexposing it to the sun. If the spirulina is dried properly then the dry form is just as nutritious as the wet form and can be stored for longer periods of time. A test was run on a sample of IIMSAM’s dry spirulina by a researcher in Nairobi that indicated it had a moisture content of 8.6%. In comparison, corn or maize flour that is sold in Kenya has to have below 10 to 12% moisture content to prevent any fungal or microbial growth. At a moisture content of 8.6% this spirulina can be stored for long periods of time, even years, if kept dry (Researcher Informant, PC) Dunga promotes his product to have a self-life of two years. Jasq Paal and Kakamega cultivation centers use solar dryers. Aviva intends on purchasing commercial dryers in 2011 that extract the spirulina from the water, dry it using dry heat, and collect the resulting powder within a fifteen minute time frame. These processors are very expensive whereas solar dryers are relatively inexpensive.

The spirulina dried on racks is then further ground into powder. Dunga and IIMSAM-Kisumu are the only ones that own a grinder. IIMSAM-Kogelo and Kakamega cultivation

sites must bring their dry spirulina to one of these sites to have it ground into powder. Aviva currently uses this simple method of drying but wants to invest in a commercial dryer and processor in the beginning of 2011. The high expense of these machines (40,000,000Ksh for the spray drying equipment) can prevent small producers from reaching the commercial level. Even though it is capital intensive its equipment is incredibly efficient; it filters the water through a series of filters to obtain the paste which is then dried via gas and the spirulina dries in powder form. These processors are self-contained so that risk of contamination is minimized, the temperature and pressure is regulated to preserve structure and nutrients, and the whole process is complete in ten to twelve minutes (Karwitha, PC).

If the wet or dry form is combined with food to be consumed, the food should be luke-warm or cold but never hot. The temperature of the food is much like the temperature of the cultivation water, too high of a temperature denatures the protein and disrupts the nutrient content. It is then further packaged into different containers. IIMSAM packages the powder into five gram packages. Dunga packages in into 100g packets for sale. Kakamega uses the spirulina for a variety of products and therefore has a variety of package sizes. The powder form is the most popular because of its long shelf life, ease of transportation, and ease of measurement. Measuring the dry output of each basin is the most common way to report production rates. Below is a table comparing the rates of production for each of the different sites.

Table 2

Site Location nt sites.	Total Dry powder weight produced per day	Total spirulina production space	Daily production (g/m ²)
IIMSAM-Kisumu	900 g	180 m ²	5 g/m ²
IIMSAM-Kogelo	1.5 kg	112 m ²	13 g/m ² *
Kakamega			
Dunga	4-5 kg	480 m ²	8-10 g/m ²
Milimani	20 kg	40,000 L	0.05 g/L**
Aviva	960 g	120 m ²	8-9 g/m ²

*the daily production was calculated from self-reported total dry powder produced per day and production space; reaching this daily production is outlandish and improbable using these basic methods

**significantly lower than an experiment testing optimal growth conditions at 3 g/L revealing that either the bio-reactor is extremely inefficient or the water contained in the bio-reactor was severely over-estimated
Note: Antenna Technology, a well-respected spirulina producer in India, reports a daily output of approximately 10 g/m² and acknowledges that this is a high output. Professor Karwitha reports that an output of 8 to 9 g/m² is a successful harvest but anything over 10g/m² in basic ponds depletes the spirulina supply and impossible to sustain in basic cultivation practices.

QUALITY CONTROL MEASURES

As mentioned earlier, it is important to maintain the water temperature and pH. All of the cultivation centers use a combination thermometer and pH-meter to monitor these parameters. The structure and shape of the spirulina spirals can also indicate the health of the strain. Over time through accidents such as overexposure to sun, improper chemical concentration, or decline in water levels the strain can weaken and lose the proper structure. For that reason a clean culture should be kept isolated as a back up and used to renew the production when needed. Dunga Spirulina was the only production site that maintained clean culture samples in a lab. The supervisor has four buckets of clean cultures covered in a cool lab with aeration tubes in the water to maintain oxygen content. Two buckets hold a strain found in Ethiopia, another holds a strain discovered in India as his original culture, and another he extracted from his ponds earlier this year. The general viability of the strain can be ascertained through other rudimentary measures. For example, if a spirulina sample is diluted in a small jar and placed in the light then three layers of different colors can be identified. One color is blue; this comes from the pigment of phycocyanin which is used to capture light for photosynthesis. The chlorophyll in the bacteria emits a green color. The final layer is red from the carotenoids and phycoerythrins.

Just as other food crops start with have some breeds that are better than others, spirulina has different strains that one can grow. The strains are derived from different parts of the world with some having higher mineral and micronutrient content. The source of the spirulina seed is also an important for quality spirulina. IIMSAM reportedly is still growing the strain that Fundi brought from Democratic Republic of Congo. This strain comes from the cultivation the Antenna Technology site in Goma, DRC. After their training sessions, the supervisors at Dunga and Kakamega cultivation sites were given the IIMSAM-Kisumu strain as their start-up seed. Dunga Spirulina and the Galaxy Youth Group in Kakamega had multiple difficulties trying to successfully cultivate the IIMSAM strain saying that it grew very slowly and maintained a more yellow-green color rather than blue-green. Then Dunga

Spirulina tried to cultivate a strain from Lake Semba but after having it tested at the lab in France realized the protein content was too low in comparison to other strains. He contacted Dr. Ripley Fox who discovered the highly nutritious spirulina strain in India called “Lonar”. This strain is used throughout India and has been very successful and Dunga Spirulina now grows this strain. Dunga Spirulina gave the Galaxy Youth Group in Kakamega this strain after the IIMSAM strain failed to grow. Since then, Dunga Spirulina and Galaxy Youth Group have had a flourishing and prolific spirulina cultivation project.

As mentioned earlier it is important to maintain the water sanitation. Some strains of this cyanobacteria naturally occur in lakes with higher concentrations of toxic blue-green algae or harmful bacteria meaning one could easily foster the growth of spirulina and toxic organisms in an artificial setting if they both exist in the seed. Harmless organisms, such as chorella and amoeba, are known to co-habitat with the spirulina as well. On the same token, other cyanobacteria that survive in environments similar to spirulina in Africa can produce harmful toxins such as cyanotoxin (“red tide”) and Nodularin R. *Aphanizomenon flos-aquae* (AFA) is one example of a cyanobacteria that was once promoted as food supplement much like spirulina and cultivated from Lake Klamath in Oregon. However most strains of AFA are toxic producing hepatic and neurotoxins (Anatoxin-a, saxitoxins, and cylindrospermopsin) so the World Health Organization has deemed its consumption a health risk (WHO, 2006).

Arthrospira platensis is a microscopic organism so indicators of nutrient level, presence of contaminants, structure of spirulina must be analyzed at the microscopic level. Spirulina is a food product therefore all of the production sites must have clearance from the Kenya Bureau of Standards (KEBS) in order to sell or distribute for human consumption. KEBS is the body responsible for evaluating the safety of the production and product in Kenya by testing the food product for microbial contamination (Veronic, PC). All of the production sites have this certification, which lasts for a year. However, spirulina cultivation should be monitored and controlled on a daily basis in order to maintain the necessary requirements for its safe production.

While KEBS may test for harmful molds it does not test for nutrient content or compare the structure of the sample to a standard of *Arthrospira platensis*. Even the range of safety tests KEBS applies is may not be adequate because Dunga Spirulina had been approved by KEBS while it was contaminated by microcystins (Jasq Paal, PC). Even if the

contamination occurred after the KEBS certification process, the possibility of such a toxic contamination highlights the need for more frequent monitoring by the supervisor. The supervisor at the Dunga Spirulina cultivation site caught the contamination because he has a microscope on site. It was also this microscope which urged him not to use the strain of spirulina being grown at IIMSAM. The IIMSAM strain no longer had a spiral structure, more like a wavy line, and had a visibly higher concentration of chlorella than spirulina (Jasq Paal, PC). IIMSAM cannot refute these claims because it does not have a microscope on site to analyze what is growing in their basins.

Testing the micronutrient content of the spirulina strains cannot be done adequately in Kenya. No lab has the facilities to cover the range of vitamins, minerals, protein & amino acids, fat, carbohydrates, etc. KKEO brought a sample to the KEMRI labs in Nairobi for a researcher to test. The lab was only able to run a basic test on the moisture, ash, iron, magnesium, and zinc content (Researcher Informant, PC). (See appendix for table) IIMSAM does not report having any such test run on their spirulina. KKEO, however, claims to have obtained a sample of their spirulina in 2009 and had it analyzed in a lab in Turkey named Soley Biotechnology Institute. The report showed low amounts in all of the minerals but also showed trace amounts of lead (Pb) which led the lab to conclude that this spirulina was “unsuitable for human consumption” (Els, PC). Again, such claims may be false especially in light of the disagreements between Els and IIMSAM directors. However, IIMSAM refused to show documents or tests that prove otherwise.

All other spirulina cultivation sites have created a partnership with a foreign lab that specializes in cultivating blue-green algae. Dunga Spirulina had its macro- and micronutrient content tested at lab in France and displays the nutrient content on the back label of the packaging. Once again, this information could not be validated since no specific name of the lab was given nor was there additional proof these nutrient contents came from his sample. KKEO has established a partnership with Soley Biotechnology Institute whom they use to test the nutrient content and safety of their spirulina. Also, there is not a unified Kenya body that governs the labels of Kenya food products dictating that the health content of the foods be displayed or if they are displayed whether it is valid. The capacity of KEBS to determine the safety of food produced and processes in Kenya is limited and the lack of government regulation on reporting nutrient content allows spirulina producers to be flexible in their safety standards or potentially falsify information to consumers.

ADVOCACY & DISTRIBUTION OF SPIRULINA

KKEO

Els Mulder has conducted the greatest amount of advocacy initiatives. Everyone that has heard of spirulina in Kenya mentions the “Dutch lady” that came to talk to them about it. These people include KEMRI researchers in Nairobi, Nyanza Province government officials in the Ministry of Agriculture, Ministry of Health, and Ministry of Public Health and Sanitation, Kisumu non-governmental organizations, and local community members. Many government officials were interested but needed more concrete details and evidence of successful human trials validating the claims that spirulina can treat malnutrition (Mary Obade, Rael Mildas, PC). However these same interested parties reported they had “not heard from the organization in Tom Mboya for long time” (Mary, Rael PC) No contact has been re-established by Els nor IIMSAM since the split in 2009. She also has pictures and narrations of personal success stories for wound and malnourishment treatments, including two twins that have been taken into the home. Majority of the pictures on IIMSAM press release with children involve these two twins or children Els previously treated.

Kisumu Kids Empowerment Organization has not been idle in its promotion of spirulina though. Before the split with IIMSAM in 2009 Els had a feeding program for 150 women and children at the Kongony site. This could have been the foundation of the IIMSAM feeding program currently in progress. KKEO has a strong partnership with Oyugis Integrated Project (OIP), a NGO located in Homa Bay that serves HIV+ and disabled patients. KKEO supplies them with a 15kg supply of spirulina on a “regular basis”. Els believes that, “ARVs may lengthen one’s life but spirulina enhances the quality of that life” (Els, PC)

As of November 2010, KKEO is not running a feeding program but will start a regimented one in January or February once harvesting from the new photobioreactor begins. KKEO has developed a feeding program protocol that will be implemented once the spirulina production reaches a sufficient level. The program has been designed to feed fifty people from the Nyalinda Kisumu slum for six weeks. The patients must be pregnant or lactating mothers or children under six years of age. The program is targeting severely malnourished but it is acknowledged that given the high prevalence of HIV/AIDS in the slums majority of these patients will be HIV+. The patients will be recruited by KKEO employed social worker

based on these criteria and the requirement that the patient attends the feeding program daily. If the patient misses one day then they are no longer allowed to be part of the program. This policy derived from Els experience with so many defaulters during her feeding program in Kongony.

At the beginning, middle, and end of the feeding program a matron nurse from a local hospital will measure the patients CD4 count, hemoglobin levels, weight, height, and mid-upper arm circumference. These measurements will be used to monitor progress. Every morning children will be given five grams of powder spirulina combined with a half-cup of luke-warm uji. The women will receive ten grams with their half-cup of uji. The protocol is clear that the spirulina should not be administered in powder form in order to prevent from promoting spirulina as a drug. Also there was concern about the manufacturing of the capsule and the need for heat or chemicals needed for the capsule to form. The powder form ensures a pure spirulina administration. After the six week program is finished KKEO social workers will follow up with the patient on a weekly basis for six weeks then a monthly basis for a year to ensure health is maintained. There was no mention what action would be taken if the patients health deteriorated during or after the feeding program. There was also no mention of collaboration with other Kisumu organizations or nutritionists in drafting this protocol or intended collaboration during the feeding program.

KKEO does not intend to promote spirulina only to HIV or malnourished patients. Taking cue from Antenna Technology, an expert in spirulina production, KKEO intends to split the administration of spirulina harvests into thirds. One third is sold to the wealthy in Kenya and internationally at a relatively higher price. Another third is sold to middle class or working class Kisumu families at a subsidized rate. KKEO did not want to mention sale prices of the spirulina harvested from the photobioreactor. This is perhaps because of an agreement with Soley Biotechnology Institute that financed the majority of the cost of the photobioreactor through their grant program. The Institute's website sells dried powder spirulina cultivated in a photobioreactor for 318 USD per kilogram with a minimum order of 25kg, which is equivalent to 25 Ksh per gram. That's a minimum order worth \$7950 USD or 636,000 Ksh! The last third is intended to supply the poor who cannot afford to buy spirulina and the feeding program.

IIMSAM

The mission at IIMSAM is to promote the use of spirulina as a means to “eradicate malnutrition, achieve global food security, and bridge the health divide with a special priority for the developing and the least developed countries.”² With the main focus on advocacy, IIMSAM has put a significant amount of effort into recruiting what they call Goodwill Ambassadors; these are nationally or internationally prominent people who are asked to use their high-profile to publicize the benefits of spirulina and the efforts of IIMSAM. Barack Obama’s grandmother Mama Sarah Obama and uncle Said Obama became IIMSAM Kenya’s Goodwill Ambassadors after Barack Obama was elected President of the United States of America in 2008. A lot of the advocacy efforts of the Dar Al Muamineem Center has been to establish a repertoire within the surrounding community offering free spirulina supplies to those interested and relying on word of mouth to promote its effects. Other advocacy initiatives have focused on partnerships with organizations and schools through Memorandums of Understanding (MOUs) or feeding programs. Even if the partnerships overextend the staff and spirulina supplies the intention is driven by the mission to promote spirulina.

IIMSAM claims that aggressive advocacy efforts have been limited by funding but progress in the local community has been made within two years. However some important advocacy links that do not require funding have not been made. For example, the Head of the Division of Nutrition in Ministry of Public Health and Sanitation and the Head of the Division of Clinical Nutrition in the Ministry of Medical Services yet to have contact or communication with IIMSAM. Both had heard of “some organization doing something with spirulina” because of the District Steering Committee Meeting disaster where IIMSAM introduced the idea of using spirulina to treat malnutrition in Turkana on November 8th, 2010. A staff member volunteered to go to Turkana on a “fact finding mission” to uncover the situation of malnutrition in the province as well as the possibility of IIMSAM opening an office and clinic there. Turkana is one of the poorest regions in Kenya with 74% of the population living in absolute poverty (GOK, 2002). Due to the arid environment, recurrent droughts, and limited infrastructure in the region, persistent security concerns at the national borders food insecurity and malnutrition remains a serious problem(Oxfam, PC). In 2009 the International Rescue Committee reported global acute malnutrition (GAM) rates above 20%

and severe acute malnutrition (SAM) rates at 3.5%. It is an area known for government corruption in food aid delivery and a large population of non-governmental organizations with a mandate to treat malnutrition in the area (Lucas, PC). While there, the IIMSAM staff member was requested to “do a feeding program” and take pictures (Elhaan, PC). The staff member found a small group of Turkana residents who were visibly severely malnourished and served them spirulina without adherence to any malnutrition treatment protocol or ethical clearing. The “feeding program” was a staged, one-time event that provided one meal for this small group of people with the IIMSAM banner displayed on a truck in the background and the spirulina recipients purposefully seated in front of the banner (Elhaan, PC, IISAM November Press Release). This so-called “feeding program” was a publicity stunt with disregard to the potential negative effects that serving a high-protein and high-iron food could have on extreme marasmus and oedemic people who may have also been dehydrated. A similar event was conducted in Kibera slums in June of 2010 (IIMSAM Press Release, June 2010). Such events may grab attention through press releases but are unethical to administer spirulina for the purpose of gaining attention without any intention of treating the malnutrition, which is a long term effort and cannot be treated by one meal. This further highlights the lack of a malnutrition treatment protocol present for IIMSAM Dar Al Muamineem Center.

The Dar Al Muamineem does have experience with a long term feeding program in Kisumu though. At IIMSAM-Kisumu the production was high enough by March 2009 to then establish a local feeding program. The feeding program takes place every morning at the Dar Al Muamineem Center in Kongony. The clinic, as the feeding program is referred to, is run by a gentleman with a diploma in clinical medicine. People interested in the clinic bring their medical cards that describe their medical history and health status to be evaluated by the clinic manager. He ensures the patient has a doctor’s diagnosis of an ailment that can be treated or relieved by spirulina. Sickle-cell, HIV/AIDS, anemic, or malnourished patients and those with majority of other ailments are enrolled in a 90 day program. If they have “no ailments” they are enrolled in a fourteen day program. However, this was unclear because part of the admittance criteria for receiving the free spirulina from the feeding program was to have an ailment of some kind. If the doctor recommends the patient lose weight, some local residents choose to use spirulina as an aid in this process.

Each adult receives ten grams of wet spirulina and each child would receive five grams of wet spirulina. Each patient brings his/her own cup to receive the spirulina as to prevent contamination of shared cups and spoons. This eliminates the possibility of communicating diseases such as oral thrush that at one point was common in a group of female patients. When there is enough funding this spirulina is combined with porridge made at the center then consumed immediately. However, during the month of November IIMSAM did not have the funds to purchase maize flour so the patients were given the spirulina to combine with porridge made at home later in the day. This means that the preparation of porridge was not controlled according to temperature, content of porridge, and amount of porridge mixed with the ten grams of spirulina. The patients are advised to combine the spirulina with warm, not hot, foods and not to add spirulina until the cooking preparation is finished. The clinic manager encourages them to add millet to the porridge because sorghum has folic acid which the spirulina lacks. He also reminds them not to combine spirulina with any carbonated beverages such as beer or soda because the carbonation destroys the nutrients as much as cooking the spirulina does.

According to the clinic manager the clinic administered wet spirulina freshly harvested from the basins to 44 to 67 patients but according to the data log spirulina was administered to 39 to 76 adults daily during the month of November. The clinic manager reports that a total of 228 people attended the clinic during the month of November. See Table 3 below for a description of the ailments treated at the IIMSAM-Kisumu clinic as listed in the daily log book for the month of November of 2010. There were a few others that attended for an undetermined length of time seeking relief from gastroenteritis or assisted recovery after a malarial infection.

The patients were only listed under one ailment even though they could have several. For example, those listed as malnourished had no other ailments while those listed as HIV/AIDS patients were often also malnourished at beginning of treatment regimen. In comparison to earlier months since the start of the feeding program, the month of November in 2010 was a lower number of patients at the clinic. Since school was in session children are not enrolled in the clinic because the feeding program starts after daily school sessions begin. Children are going to be re-enrolled starting December 1st. For the adult population there were 26 males and 41 females that attended daily, which adds to a sum of 77 and is above the clinic manager's report of attendance.

Table 3: Number of Patients treated for each Ailment at the IIMSAM Dar Al Muamineem Clinic, November 2010

Ailment	Number of patients daily
HIV/AIDS	10-24
Anaemic	6-15
Sickle-cell	6-7
Malnourished	5-11
Hypertension & Weight Loss	2
Pelvic Inflammatory Disease	2
Peptic Ulcer Disease	3
Arthritis	2-9
Diabetes	1
Wound	2

It is also important to note the wide range of attendance of the patients. In order to accurately analyze the health effects of spirulina, the administration of spirulina must be done on a daily basis and in a consistent manner (i.e. always with porridge or without). However, the patients enrolled at the feeding program have done so on a voluntary basis. IIMSAM does not have any binding agreement with them nor does IIMSAM have the staff capacity to follow up with defaulters to encourage them to continue attending the clinic or to uncover why the participants have not been attending on a regular basis. Granted, majority of patients attend on a regular basis and are only absent one day at a time. By having a large fluctuation in attendance numbers and a wide variation in ailments treated, it is very difficult for IIMSAM to make a statement that established a cause-and-effect statement between spirulina and general health improvement of these patients.

The Dar Al Muamineem IIMSAM Centre reports that it is able to treat “500 malnourished adults with five grams per day or 250 HIV positive adults per day with consumption of ten grams per day” at the daily feeding program that also includes health monitoring clinic. Despite this report, the clinic director reports that there is often a shortage for his 36 to 66 patients a day at the clinic. This is an additional weakness in consistency of spirulina administration that prevents the organization from making strong statements linking

spirulina consumption and improved health. This press release also implies that malnourished patients only receive five grams of spirulina per day. However, the IIMSAM staff all report that it is necessary to give both malnourished and HIV patients ten grams of wet spirulina a day; the clinic manager dispenses ten grams to each adult patient. The discrepancy between reported intended protocol and actual practice highlights the issue that IIMSAM does not have a written protocol for spirulina administration--for the malnourished, HIV+, or any other patients.

Progress is monitored through weight measurement and blood pressure (for hypertensive patients) once a week after admittance. HIV/AIDS patients bring their medical cards to report their CD4 counts, which are tested every three months. There is no clear dismissal criteria other than the end of the ninety day period. However, several patients who were enrolled in March of 2009 are still enrolled in the program because a significant drop in productivity at the IIMSAM Dar Al Muamineem basins in July 2009 that caused the clinic to be suspended for a period of time. The clinic manager has kept them in the program in order to have the patients fulfill the full consecutive ninety days. He keeps track of the days of attendance and defaulted days to count a total of ninety days before dismissing them.

After being cleared from the program, the patients will have to pay for spirulina if they want to continue using it. Even at the subsidized rate of five shillings per gram or a total of twenty-five shillings for a daily dose of five grams the majority of the patients interviewed stated they did not have the financial resources to purchase spirulina for themselves. Not only that but the patients were unclear where they could buy spirulina after the program. The clinic manager had to clarify that if the patients were interested in purchasing spirulina IIMSAM the Kisumu staff would have to request a delivery from the Kogelo cultivation site to provide it.

The IIMSAM-Kogelo sites distributes spirulina in powder form to women and grandmothers in the Kogelo area that are apart of Ochome's NGO. This site is also the one to supply Camp Maradona. A partner of IIMSAM, Camp Maradona, uses a children's football league of 37 teams in Nyanza to provide spirulina-fortified food to participants and educate them about the spirulina sustainable development agenda of IIMSAM. The children are offered spirulina-fortified porridge (using the wet spirulina) after select games. There is not a large enough supply to distribute spirulina at practices or at every game during the league's season.

The Dar Al Muamineen Centre claims to distribute spirulina to surrounding health clinics in villages Kogony, Kogelo, Kanyamedha, Nyalenda, Obunga, Manyatta and Kanyakwar. However the only “clinic” in Kisumu actively distributing spirulina is the one at the Dar Al Muamineem Center. The residents of these bordering villages within a 2 kilometer walk of the center are the ones that comprise the population at the clinic. In the beginning of 2010 the center distributed spirulina to feed children at schools and children’s homes in Kisumu such as Jean’s Academy for street children, Shaurimoyo Primary School, Kanyamony Primary School, Mama Ngina children Home and Kanyamedha Primary/secondary School. The schools mixed the wet spirulina supply, which was equivalent to one teaspoon per child, with the uji that had been given as a separate donation from the area MP. Kanyamony Primary school fed all 480 students with spirulina-fortified uji. Mama Ngina has 47 children at the home that were fed. Kanyamedha Primary has over 1,000 children at the school but only 80 students and all 20 teachers received the spirulina-fortified uji. Jean’s School had a feeding program from April to June. However these deliveries for these three schools and children’s home stopped in June when production levels again dropped too low. Around that time the MP’s supplies of uji flour had run out from the previous year’s donation so the feeding program stopped altogether. Shaurimoyo received spirulina during the month of September, 2010. Between Shaurimoyo and Jeans Academy had a combined number of 250 children. It is surprising that IIMSAM chose to supply several different schools when not all of the children were served at each school.

The Dar Al Muamineem continues to expand efforts with feeding programs with other organizations despite the unreliable production and lack of supplies. They had a meeting in October 2010 with a potentially new partner Women Fighting Aids in Kenya (WOFAK), Kisumu branch, in order to start a draft of a MOU in which 20 mothers would receive a daily spirulina supply. They are also in the works of a partnership with Joyland School for Disabled Children. They would like to establish offices in Mombasa, Busia, Voi, and Turkana but that possibility seems limited at best.

Dunga Spirulina

The supervisor of Dunga Spirulina is adamant about the need for advocacy. He places heavy emphasis on his role to raise awareness about spirulina first within the Kisumu community. Raising awareness for him includes educating pharmacies, doctors, and other

healthcare professionals on the specific aspects of spirulina and the benefits from its consumption. His main target population are the HIV+ patients, support groups, and NGOs working with the large HIV/AIDS population in Nyanza. He has been active in the town center going to support meetings to talk with community health workers and HIV+ patients to sensitize them. He chose this target population not only because it is a large in number but also because HIV+ patients have particular nutritional requirements that spirulina can address with a few grams a day. Antiretroviral treatments are very strong drugs to the point of being toxic at times, he says, that without proper nutrition HIV+ patients won't survive. He promotes spirulina at least as a food supplement or better yet a "whole food" but never as a drug, herbal medicine, or extract. Just as IIMSAM and KKEO carefully present spirulina, he does not want spirulina to be seen as a miracle cure for HIV.

The IIMSAM Dar Al Muamineem Center press release reports that Dunga Spirulina "can accommodate 600 malnourished adults per day" disregarding that Dunga Spirulina does not run a feeding program (IIMSAM website). While the supervisor at Dunga Spirulina believes the humanitarian component of spirulina distribution is important, which includes distributing spirulina for free to those in greatest need, he has entered spirulina cultivation as a business venture. After creating awareness and a market the next step is for him to establish a good brand of spirulina that has a reputation for being reliable, consistent, and a reputation for simply working. He is already well on his way with this sophisticated production with high quality measures in place and modern packaging. At a rate of five shillings per gram (sold at 500/= for 100g packages), he views spirulina as a "cost-effective form of nutrition" because for 20 to 25/= a day a client can get majority of the vitamin and minerals needed in a day. Again the question of affordability for the poor arises. He plans to follow a business model similar to KKEO where wealthier individuals and NGOs serving HIV+ pay for spirulina. This income is used to finance the free distribution to those who cannot afford it but can greatly benefit from its consumption.

The final step after having a working base of general acceptance and knowledge of spirulina in the community is to then promote spirulina cultivation. There is great flexibility in cultivating spirulina. One can grow it in buckets, greenhouses, open ponds with plastic lining or concrete, or up to mechanized set-ups. Dunga Spirulina cultivation is set-up in a simple manner as a way to later show people how to grow it feasibly at community levels. Once a significant following has been established it will be easier to get funding for those

ventures. Dunga Spirulina is founded on the belief that if done correctly spirulina has a great future as a progressive crop.

While IIMSAM's principles and efforts fall in line with the ideals that Dunga Spirulina proposes, Dunga Spirulina has a much more focused plan with a natural progression. Dunga Spirulina, for example, has a label and packaging for its spirulina in order to promote a brand identity while publicizing and selling. IIMSAM's efforts are so scattered and each initiative is started only to be reeled back because of "insufficient funds". In the long run starting and stopping programs will only make the organization seem unreliable and the spirulina product unreliable as well.

Galaxy United Youth Group, Kakamega

The Galaxy Youth Group is essentially a micro-enterprise group emphasizing the potential of spirulina to employ youth through the cultivation, maintenance, and value-addition production of spirulina products. Members of the group age from eighteen to thirty years old. They are using their experience in growing mushrooms as a health food and food supplement as a basis for their marketing and production of spirulina in Kakamega. This group produces a range of products from spirulina soap, shampoo, skin oils to food. The spirulina food is distributed in powder form with varying sized bottles as well as in 500mg capsules. In order to produce the powder the group must bring the dried spirulina chunks to Dunga to use their grinder.

They believe spirulina has serious potential to employ a range of people because it has a large output in comparison to the amount of land needed to cultivate it. Spirulina also requires only a fraction of the water and chemical inputs that other cash crops, such as maize, require. The supervisor regards the high demand for maintenance a positive thing because it provides constant source of employment. If this group is financially successful enough to pay the member of the youth group then IIMSAM and Dunga Spirulina's aspirations of promoting spirulina as business at the community level may be quite practical and feasible.

Aviva

Aviva's product line represent the commercial distribution of spirulina. While Aviva is still serving a small customer base the company with a small supply of spirulina the company is on the path to reach a sophisticated commercial industry thanks to the marketing and

branding efforts of its owner and founder Professor Karwitha. Spirulina is one of twenty-five health food and body care products that Aviva sells. She is targeting the wealthy or at least those that can afford to pay 2,200/= for a 100g supply of spirulina. After her production has reached a large scale with lower cost of production then she will lower her prices for the poor at five shillings per gram and have smaller packets (5g each) of distribution so they can afford it as well.

She is promoting Aviva's powder spirulina, brand name K'nana, as a "superfood" not a drug or food supplement. She does not put much emphasis on the high protein, iron and mineral content of spirulina because many other foods have these nutrients. In order to emphasize how much of a breakthrough spirulina is as a superfood she highlights the other aspects of spirulina that fit in the new age of nutrition, such as the SOD enzymes, GLA, n and phycocyanin content. Professor Karwitha wants to avoid the perception of spirulina as a drug because then the pharmaceutical companies will start to view it as a competition as an HIV treatment.

The special properties and biochemistry of spirulina are hard to explain to someone who is not familiar with the field of human biology and nutrition. In order to explain the health benefits very simply to the general public Professor Karwitha uses a creative analogy. Knowing that Kenyans generally view fish as a healthy food, she explains that spirulina can be used as a healthy fish feed and can lead the fish "meat" to be even healthier to consume. However, one does not need to eat fish or deal with the fishy smell to get the same benefits he or she can simply drink the spirulina added to water. For a less elementary approach she tells people spirulina has seven main effects: cleaning the body cells (clean the inside just as one showers to clean the outside), supply nutrients, repair worn out cells, encourage growth of new cells, enhance immunity, and protect the immune system by lowering bad cholesterol and toxins, and provide internal UV protection. It is unclear how spirulina provides internal UV protection or why one would need internal UV protection.

Unlike the other spirulina producers in Kenya, Professor Karwitha is skeptical about the possibility of growing spirulina at the community level as a micro-enterprise venture. In order to grow spirulina the producer needs to be very familiar with the biochemistry behind the pH and nutrient levels in the water and how that affects the health of the microscopic organism. One needs to have a depth of understanding about the chemicals beyond simply adding sodium bicarbonate to make the pH level increase and a significant portion of the

unemployed in Kisumu are uneducated to that level of biochemical knowledge. “This is high science not just for the average farmer,” she says (Karwitha, PC). She has hired a biochemist and nutritionist to run the Aviva cultivation because she wants to ensure the high standards are met and she can rely on them to properly solve problems while she is away from the site. She knows they understand the diligence and attention to detail that is required to cultivate a safe (uncontaminated), nutritious spirulina. As an “agricultural nutritionist” she understands every detail of the value chain from cultivation, harvesting, production, and processing to the consumption of her product. She believes IIMSAM is still lacking this expertise which is why she is facilitating a Memorandum of Understanding between IIMSAM and agricultural researchers of Kenya Agriculture Research Institute. She was asked to be a Goodwill Ambassador for IIMSAM with her Aviva line of products but she has declined because she says she has done a significant amount of global traveling doing research and is no longer interested in traveling. (Karwitha, PC)

Other Alternatives to treat malnutrition

Spirulina is not the only health food being promoted in Kenya to increase household food security and manage malnutrition. Other efforts from the Ministry of Agriculture include promoting the use of kitchen gardening or “multi-story gardening” to grow vegetables at the home. They have also started encouraging farmers grow other leafy vegetables that are higher in nutrient levels including amaranth, spiderplant, and african nightshade. See Table C in Appendix for a comparison of nutrition values. They also have encouraged people to harvest the leaves from the moringa tree because of the high beta-carotene and calcium levels. The head of the Nutrition branch in the Gender & Home-Economics Subdivision of the Ministry of Agriculture wants to encourage women’s groups on the coast to mimic the Mitengo Women’s Group based in Lusaka, Zambia who has had a successful production and distribution of the moringa tree leaves. The nutrition branch encourages production and consumption of locally grown foods so that they are readily available, easily accessible, and affordable for families to have a balanced diet. The advantage of these crops is that they are already well known and accepted as a food source in Kenya.

Mushrooms are another popular food being grown to manage malnutrition. Before growing spirulina the Galaxy Youth Group in Kakamega grew and processed mushrooms that are sold at local supermarkets. Mushrooms, like spirulina, are considered the next answer for

microenterprise agriculture because they require little space for cultivation and reduced amount of water and chemical inputs compared to other crops.

The most common treatment for severely malnourished--categorized as kwashiorkor or marasmus patients---is the consumption of ready-to-use-therapeutic-food (RUTF). Ready-to-use-therapeutic-food are high-calorie, nutrient dense single serving packets. In 2007, the United Nations officially approved the use of therapeutic foods for the treatment of acute malnutrition in children (Dibari, 2010). The most popular RUTF Plumpynut^(R) has been in existence since 1990 and is currently recommended in the Kenya Ministry of Medical Services National Guideline for Integrated Management of Acute Malnutrition. While the different brands of RUTF--F100, Plumpynut, eeZeePasteTM NUT, Medika Mamba, Valid Nutrition Peanut Form RUTF, Revita^(R) Ligua Health Chocolate--vary in ingredient composition but they do not require the addition of water nor do they need to be cooked or prepared in anyway. This allows the RUTF to be stored for long periods of time and can be administered without additional resources (Kapil, 2010). The RUTF packets are usually distributed at local health clinics. The single serving packets, ease of administration and transportation allow for child severe acute malnutrition cases to be treated through home-based care. Children have found the taste of the peanut-butter based food to appealing to taste so administration of Plumpynut has had great results. It has been repeatedly found that “home-based management with Ready-To-Use-Therapeutic Food (RUTF) has been found to be associated with better outcome than standard therapy in the hospital (Kapil, 2009). This ease of home-based care has also lead to the use of RUTF as a malnutrition treatment for adults in addition to children. These RUTF treatments have gained favor among international health organizations that treat large populations suffering from malnutrition during food crises such as drought, famine, or prolonged conflict.

However, RUTFs do have a number of disadvantages that discourage its continued use as a malnutrition treatment. RUTFs, like Plumpynut^(R), are produced internationally and therefore incur a large cost for nongovernmental health organizations and clinics to import (International Malnutrition Task Force, 2008).³ Since it is not produced locally as part of the diet, recovery from malnutrition is dependent on the RUTF and can become only a temporary treatment since the patients do not have access to the RUTF once the aid ends.

Despite these disadvantages, RUTFs F-75, F-100, and Plumpynut are the treatments given according to government protocol for severely malnourished, moderately malnourished, and hypoglycemic patients in in-patient and out-patient therapeutic care. This government protocol was published in June 2009 with the guidance and support of nutrition experts in the Ministry of Medical Services, Ministry of Public Health and organizations such as the World Health Organization, Concern Worldwide, and UNICEF, Save the Children-UK, MERLIN, Samaritan Purse Kenya, International Medical Corps, World Vision Kenya, Islamic Relief, and World Food Programs (WFP). IIMSAM was a fledgling organization in Kenya by June 2009 but as an international organization it should have the experience and understanding of malnutrition to make a contribution to the publication of the first integrated program of acute malnutrition in Kenya. In fact, none of the spirulina producers in Kenya, IIMSAM included, that are trying to promote spirulina as malnutrition treatment have any ties to a nutrition expert. The Kenya Goodwill Ambassadors for IIMSAM are celebrities and businessmen and none of them have a background in malnutrition research. The lack of expertise was apparent during the “fact finding mission” to Turkana in November when the IIMSAM staff member could not answer questions on what parameters are used to monitor the malnourished patients at their clinic in Kisumu or explain the nutrient contents of spirulina.

CONCLUSION

The advantages of spirulina cultivation is that it requires less land space, water, and chemical inputs than traditional cash and food crops such as maize. This is an eco-friendly crop in the sense of land conservation as well as its high consumption of carbon dioxide. The high protein, iron, vitamin and other micronutrient content of spirulina is a definite advantage for those seeking to improve their nutrient consumption. A huge advantage of spirulina is that it can be store for long periods of time, easily transported, and easily dispensed.

There are numerous challenges facing spirulina cultivation in Kenya. Water access is limited throughout the country, even in Kisumu and especially in Turkana. Drilling a bore hole or having piped water for ready access to safe water is a must for any spirulina cultivation site to prosper. The possibility of contamination in the pond to contamination by workers during harvesting and processing is a danger for all patients consuming spirulina. Effective quality control measures to monitor the water content, pH, and temperature is another requirement that should not be overlooked. While all of these measures require a significant investment the cost of chemical inputs is the greatest. These costs limit the ease in which a spirulina cultivation sight can be started and maintained. With the ability to harvest spirulina six days after “seeding” the water and the ability to harvest eight to nine grams per square meter daily, there should be a promise for a quick return on the upfront investment. However spirulina is still not well known in Nyanza Province nor in the rest of Kenya. Significant amount of effort needs to be put in to advocacy and creating a national market. If efforts continue to target HIV patients spirulina could be associated as a HIV treatment and not as a food helpful to a wide range of ailments and people. The stigma against HIV that is still present in Kenya could limit spirulina to that market. At the same time spirulina production requires people that are serious and dedicated to have successful production. A contamination or death caused by spirulina production would kill the the possibility of spirulina being used as a malnutrition.

Currently, spirulina is not being used as a malnutrition treatment even though three of the Kenya producers promote that as the main purpose of the cyanobacteria. If spirulina administration and distribution continues in the current trajectory it will not be accepted in Kenya as a malnutrition treatment.

RECOMMENDATIONS

IIMSAM and KKEO needs to consult the National Guidelines for Integrated Management of Acute Malnutrition for guidance on how to manage an out-patient feeding program. I would encourage IIMSAM to develop their clinic in accordance with the monitoring systems suggested in the guidelines from health status monitoring and follow-up of defaulters. They especially need to be wary of administering spirulina to patients that are dehydrated, have oedema, have been receiving Vitamin A and iron supplements. Toxicity is a possibility if they target the same beneficiary as other malnutrition programs in the area that serve fortified maize flour, micronutrient sprinkles, RUTF, or multi-vitamin tablets. For these reasons, I suggest that spirulina feeding programs target acute moderately malnourished patients through out-patient feeding programs as a prevention of severe malnourishment and facilitating recovery from severe malnutrition. There are clear criteria for moderately malnourished children as outlined in the National Guidelines for Integrated Management of Acute Malnutrition in Kenya. For example, children under five have a mid-upper arm circumference of 11.5cm to 12.4 cm, do not have oedema, and present with poor feeding habit (Ministry of Medical services, 8). Criteria are outlined for each population sector from infant less than 6 months, children aged 6 to 10 years, adolescent, adults, and pregnant and lactating women. Marketing to a wide range of demographics will help the spirulina market grow quickly.

I would also recommend that IIMSAM and Galaxy United Youth Group obtain a piped water supply and expand their rain water storage capacities in order to prevent damage to spirulina supplies because of water availability.

Both of these organizations need to have greater contact with Division of Nutrition in the Ministry of Public Health and Sanitation so that government officials can offer more consultation services and help in advocacy of spirulina once they are more educated. Furthermore all of the spirulina producers should stay abreast of the upcoming national micronutrient survey starting in the beginning of 2011. If they can be of any assistance during the research process it will help them in their advocacy and informing more Kenyan researchers on spirulina. The results of that survey will be key for their strategic planning in the near future.

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Appendix

Table A: Metabolic Nutrient Content of Spirulina sample provided by Els Mulder

	Content amount	Indicates
Moisture	8.6%	really dry, can be stored for long periods of time
Ash	19%	inorganic material, mineral content is high; is usually 2.1% for foods
Iron	117.5 mg/ 100g sample	
Magnesium	110.8 mg/ 100g sample	
Zinc	96.0 mg/ 100g sample	

*Test results reported by Phillip Ndemwe

Table B: Nutritional Facts of Dunga Spirulina as supplied on package

Nutrition Facts		100g	
Packing Size		100g	
Serving Size		10g	
Amount Per Serving			
Calories 29		Calories From Fat 6	
Protein	6.4gr	64%	
Carbohydrates	1gr	10%	
Lipids	0.6gr	6%	
Minerals	0.9gr	9%	
Moisture	0.7gr	7%	
Vitamin A	15,030IU	Chromium	0.028mg
Vitamin B1	102 mcg	Germanium	0.006mg
Vitamin B2	99 mcg	Phosphorous	100mg
Vitamin B3	621 mcg	Magnesium	40mg
Vitamin B6	13 mcg	Copper	0.12mg
Vitamin B12	7mcg	Potassium	160mg
Inositol	2mcg	Manganese	0.5 mg
Biotin	0.9mcg	Selenium	2mcg
Folic Acid	0.9mcg	Inositol	6.4mg
Pantehnoic A.	2mcg	Calcium	43.33 mg
Selenium:	2.00 mcg	Iron	5.67 mg
Manganese:	0.30 mg	Iodine	4.00 mcg
Sodium:	83.33 mg	Zinc	0.13 mg
Pigments			
Phycocyanin (blue)	1500-2000mg		
Chlorophyll (green)	115mg		
Carotenoids	37mg		
Beta Carotene	8mg		
Zeaxanthin	0.95mg		
Based on a 2000 Calorie diet			

Table C: Opportunities for Higher Nutrition; composition per 100g edible portion of leaf

	Amaranth (Mchicha)	Spiderplant (Mwangani)	African nightshade (Mnavu)	Cabbage (Kabiji)
Iron (mg)	8.9	6.0	1.0	0.7
Protein (g)	4.6	4.8	4.3	1.7
Carbohydrates (g)	8.2	5.2	5.7	6.0
Fibre (g)	1.8	1.4	1.3	1.2
Vitamin C (mg)	64	13	20	54
Calcium (mg)	410	288	442	47
Phosphorus (mg)	103	111	75	40
B-carotene (mg)	5716	10452	3660	100
Calories	42	34	38	26

Table reproduced from Kenya Resource Center for Indigenous Knowledge, National Museum of Kenya

Narrative Self-Criticism

This was an exploratory research that required personal initiative to investigate the networks and players involved in spirulina cultivation. I set out to discover the malnutrition related aspects of the cyanobacteria. In order to do so I had to contact those that produce, sell, and consume spirulina throughout Kenya. As a result of the high concentration of spirulina producers in Nyanza that is where I conducted most of my research.

The strength of my paper is the detail I was able to uncover about the cultivation, harvest, and processing of spirulina. I was able to start with one or two names and phone numbers and expand the number and diversity of people interviewed through networks. I found it a personal triumph to not only uncover a lot of the hidden issues in spirulina but also persevere in my research when some IIMSAM staff members tried to distract my research and basically stop my research. The objectives and goals of the research did not change from the time of my ISP proposal until its final submission which indicates that I stayed focused and created a scope of research that was manageable within the limited time frame. I believe I maximized my research time and investigated all of my leads for information.

The weaknesses of this project are the gaps in information from nutrition-related experts. I was unable to have an official interview with Ministry of Health Nutrition Division officials in Nairobi. Unfortunately I was not able to meet with other nutrition based organizations such as Valid Nutrition or UNICEF or even in Nyanza hospitals to find out more details on malnutrition programs or the physiology of malnutrition. I wish I had been able to find researchers in Kenya that could offer more valid and specific information on spirulina. I would have liked to talk with directors or researchers of Kenya Agriculture Research Institute (KARI) to hear their perspective on spirulina cultivation. Since I have a lack of contacts in other areas of Kenya I was unable to explore leads in Mombasa about the possibility of spirulina cultivation there. I think the uses of spirulina may have been different and with different demographics targeted. This contrast would have added another useful dimension the paper.

All said and done I feel that I have earned an A-.